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LONG ENDURING METEOR TRAINS

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(Read April 24, 1941)

THIS research is a continuation, along additional lines, of that by the late C. C. Trowbridge, which appeared during the years 1907–1911. It was made possible by a grant of $1000 from the Penrose Fund of the American Philosophical Society in 1935. With this Dr. C. H. Cleminshaw was brought to the Flower Observatory and for about eight months devoted his day work to meteor train phenomena. On his resignation, I took the work over completely and, as my other duties permitted, have slowly pushed it to a conclusion. During the past several months I have been efficiently aided by my wife, Mrs. N. S. Olivier, who has examined hundreds of volumes for references and aided in preparing the data. To both her and to Dr. Cleminshaw I am under deep obligations.

The data here presented came from the following sources. (1) All the records gathered by Trowbridge and turned over to me by the Meteor Committee of the National Academy of Sciences. (2) The records collected by our own member, the late Prof. Cleveland Abbe, Sr. (3) The immense mass of data in my hands, due to the work of the American Meteor Society. (4) Records sent to me privately by astronomers, mostly foreign, in greatest number from the U.S.S.R. (5) Reprints on all phases of meteor work sent me from many countries. (6) Examination of from 2000 to 3000 scientific journals and books, in various languages, in which references to meteors might be expected. From these sources I have prepared Table I containing 1336 trains which either lasted at least 60 seconds or which, if shorter in duration, showed actual drift. This table, along with Table II which has further data upon 583 of the 1336 mentioned, gives in condensed form the salient facts upon every train. Table II has specific data on heights and drifts, the latter being the original chief aim of this research.

Two men only have published extensively on this subject, Trowbridge in America in 1907–1911 and Kahlke in 1921 in Germany. The present paper not only contains the hundreds of trains observed since 1921, but by more careful search of old records has perhaps doubled the numbers actually used by the two scientists mentioned in writing their papers. As I do not consider myself competent to attempt a complete physical theory based upon the observed facts, I have contented myself with presenting them in such form that this paper should be fundamental to future studies of currents in the upper atmosphere. The reason for this statement is that it appears to be based upon far the largest existing collection of data on the subject.

The following deductions are of special interest:

(*A*)	Night trains	Beginning height	102 km	(51 cases)
		End height	74 km	(54 cases)
(*B*)	Day trains	Beginning height	57 km	(19 cases)
		End height	30 km	(22 cases)

(*C*) Based upon the above values; these velocities were found:

Night trains	175 km/hour	(30 cases)
Day trains	133 km/hour	(8 cases)

Based upon assumed values for heights, these velocities were found:

Night trains	214 km/hour	(41 cases)
Day trains	121 km/hour	(4 cases)

In the velocities, where there were two or more values for the same train, the average value was used in the above tabulation.

This paper was finished too late to make a very complete analysis of the directions of drift. In any case this should be done by a trained meteorologist, as it will doubtless be as soon as the data are published. The only striking preponderance of drift that I find from a preliminary study is a considerable one to East for day trains over the Eastern Hemisphere land mass, and a less striking one of drift to West for the night trains over the same area. For North America, the Oceans, and the few from the Southern Hemipshere, each group treated separately, nothing striking is found except a preponderance of night trains drifting to

[1] Aided by a grant from the Penrose Fund of the American Philosophical Society.

the North for America. This is contrary to Kahlke's findings.

The average for the two values, measured and assumed, for night trains is 194 km/hour, for the day trains 127 km/hour. As the mean levels are 88 km and 44 km respectively, it seems to indicate a general increasing wind velocity as we go higher. It will be noted that these means, 88 km and 44 km, represent quite well those for the Kennelly-Heaviside Layer at night and perhaps also in the day.

The most casual study of the data will show at once that the drifts are complex and not simple. The same train will often indicate many superimposed currents of different velocities and very different directions. Incidentally it should be noted that for all trains observed from only one station the drift given is merely a projected drift and not the real one. Only for those trains which were triangulated could the true direction of drift be found, or indeed the true heights of the trains. Some parts of the trains, even their centers, may be at times stationary, while the rest has considerable velocity. Further there is proof in certain cases of components both upwards and downwards, indicating vertical convection. There are also whole trains which show no appreciable distortion or motion, others however in which violent forces seem at work. It must be remembered that the body which causes the train is a meteor, a solid body of from a few inches to a few feet in diameter. This, striking and penetrating our atmosphere, with a velocity of from 15 to 75 km/sec, can only make a cylindrical path of small cross-section, no matter how many miles in length. Yet in less than one minute this path is often defined by a cylindrical glow fully a kilometer in diameter, which in many cases grows even larger. Besides gas diffusion some type of repulsive force is indicated. Again the opposite phenomenon is seen; the ends of the train contract towards the center, apparently, and the whole becomes an elliptical ball of light, which in turn sometimes expands in diameter or merely diffuses away.

Table III, giving monthly totals for all years, shows a great excess for November, August and October, in order of magnitude. The great Leonid showers with some Bielids cause the November maximum, the excellent annual Perseid shower that of August, and the smaller Orionid shower of October gives the excess for that month. Two out of three of these showers are certainly connected with comets, the third probably so. This would indicate that cometary meteor streams were good breeding grounds for meteors which would produce long-enduring trains. Yet in advance no prediction can be made as to *what* meteor will or will not leave such a train. Take the excellent 1931 Leonid display for example. In this I saw some bright Leonids leave trains persisting up to 10 minutes, yet equally bright ones and of similar color and appearance leaving trains which vanished in from one to two seconds. Why the difference? No one knows.

As said, the stratum contained between 102 and 75 km from the Earth's surface roughly defines the region in which long-enduring night trains are found. For day trains we found the limit 57 and 30 km only. Yet it would be erroneous to believe that we are dealing with totally different phenomena. The best example is the great meteorite of 1933 March 23, our No. 1103, seen over parts of Texas, Oklahoma and New Mexico. This I reported on here in 1935. True this fireball came in twilight, yet we found a continuous train from 100 km to 25 km which lasted fully an hour at upper levels, at least 10 minutes at the lower levels, and which showed all typical train characteristics. We may also refer to our numbers 45, 393, 567, 604, 778 and 1081? as cases in which the strata are overlapped. There are others as numbers 588, 699, 750 and 1264 which would indicate a higher upper limit to the night stratum. Of course, some of these abnormal heights may well be accounted for by errors of observation; it seems impossible that this can explain No. 1103. In any case the debris of the meteor, fine dust and molecules of gas, are present all along the path. Exactly what optical effects the moving mass itself produces upon the atmospheric molecules it actually meets and those it brushes aside, and what further effects are caused by the mixing of the debris mentioned, may in part be deduced or inferred from the tabular data.

It should be said that vast numbers of the brighter meteors leave trains visible one or more seconds. Such trains are not limited to the stratum discussed. The choice of a 60-second duration by me for this paper was purely arbitrary, but I think was made on sound reasoning. How long a train is visible depends upon many factors, such as clearness of sky, absence of moonlight etc. Also the use of a field glass or telescope often prolongs visibility many times. The use of optical aid in the study of trains is therefore highly recommended. Meteors themselves appear usually at considerably greater heights than the upper level of the train stratum. They disappear, on an average, about its center. This indicates that meteors which leave long-enduring trains penetrate lower than most. This latter fact would in turn indicate a comparatively larger mass than the average, which would give a better chance for survival. As to slow or great velocity being the deciding factor, we find the very fast moving Leonids often leave fine trains. The number seen in the fine Bielid showers was much smaller but so was the average magnitude of the meteors themselves. The same may be said of the fine Draconid shower on 1933 October 9, when the meteors were both fainter and slower than Leonids. Knowing nothing of the average mass of meteors in the different streams, though I have no reason to believe that they differ to any great extent, there are not data sufficient to say whether the velocity is the decisive factor. The elements present in a given meteor may have much influence.

In closing I desire to emphasize that I have only analyzed my data for certain purposes, largely of an astronomical nature. Indeed the long experience I have had in practical meteor work, covering over 42 years, and my wide acquaintance with others in the same field have given me a special opportunity for carrying this research as far as I have. I now willingly hand on the results to the physicist to supply the necessary theories to explain fully the causes of the phenomena, and to the meteorologist to apply the new data to studies of the upper atmosphere.

Table I

The columns are headed as below and the following notes explain their contents.

No.—Serial number, also repeated in Table II.

Date—Astronomical date (old style) which begins 12 hours after civil date, i.e. at noon not midnight.

Hour—Expressed from noon as zero. Local time used when known.

Type—N denotes a train seen at night, T one in twilight, D one in daylight, i.e. with Sun above horizon. It is obvious that some cases are on the borderline and another investigator would classify otherwise.

λ, ϕ—The approximate longitude and latitude of observer(s), or of region over which meteor passed. In latter case the end point would be chosen, if known.

Radiant—Given if known. One or more ? denote increasing uncertainty.

Maximum Magn.—The highest estimated magnitude either in stellar magnitudes or by letters. M designates (full) Moon, S the Sun, Br brilliant, F fireball, B that object burst,—that no information is given as to magnitude. However, in most such cases, except for shower meteor, we may assume F would be entered. x denotes that meteor itself was not seen, only its light and the train that was left.

Duration—Given in minutes and fractions,* denoting the duration was determined using a telescope, field glass etc. This is usually much longer than visibility to unaided eye.

Motion of Train—S denotes spiral, Z-shaped, or serpentine; C curved; R ring-shaped, whole or in part; B ball of light; L cloud-shaped; D that direction of drift was derived; Z no observed motion, hence zero drift; Y presumed that there was very little drift; K comet-like; E expanded; M definite motion, no direction given; P drawings, diagrams or photographs given; A uncertain whether duration of meteor or train was meant.

References—The usual ones for current journals. 'Greg' and 'Biot' refer to their catalogues. A few books are mentioned by name. Jahr A + G refers to Jahrbuch für Astronomie und Geophysic for 1901, which has a table giving partial data as to many trains. In a number of these cases I regret inability to find the original reference. Where the originals were found, this designation was omitted. The latter remark may be repeated as to Greg. After 1900 an increasing number of personal reports has been sent to me or to the American Meteor Society, which I direct. Single reports bear the observer's name. U S N Hy O designates reports to the Hydrographic Office U. S. Navy, largely published in its Bulletin. HC followed by a number denotes the serial number in Katalog der Bestimmungsgrössen für 611 Bahnen Grosser Meteore; Wien Ak. Vol. 100, 1925, by von Niessl and Hoffmeister. K followed by a number refers to the serial number in Kahlke's tables in Meteorschweife und hochastosphärische Windströmungen; Ann. Hydr. Sept. 1921. The words stone, iron, etc., mean that this type of meteorite was found as a result of the appearance of the fireball mentioned in table.

Note: The 1936 reports of N. Guriev were made at a place named Khodja-Obi-Garm, Varzob district, U.S.S.R. The only place that approximately fitted this name was in $\lambda = 63°$ E $\varphi = 36°$ N. This identification may be in error.

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α	δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	°	°				
1	-32	10	26	-	N	China				Br	Sev.	R,D	Biot.
2	-12	5	23	16:	N	China				B	90+		Biot.
3	90				N	China				F,B	Sev.	Y	Jour. de Phys., 38,348,1818
4	584	12	-	12:	N	China							C.R., 12,501,1842
5	811	3	30	4:	D	China				Br,B	H S	Z +	Biot.
6	903	3	-	-	-	China				> M,B	3 D	Z + ??	Biot.; near vernal equinox!
7	935	9	21	-	-	32E	28N				?	S	Greg., stone
8	1001	12	14	-							Long	S	C.R., 12,506,1842
9	1013	3	16	N ?	-	0	35N			M	15		Greg.
10	1028	5	16	16:	N	China				F,B	Long	L	Biot.
11	1036	5	21	17:	T	45E	33N			S	Long	S	Jour.,Osmania Univ., 3,1935
12	1039	4	6	-	-						Long		C.R. 12,506,1842
13	1464	4	5	-	N	China				Br	Long	S	Biot.
14	1488	9	21	22:	D	China				Br	Long	L,S	Biot.
15	1492	9	21	-	N	- W	- N			F	Long		Boston Jour. 1892 Sept. 21
16	1533	10	24	-	N	China		Leonid ?		Br	Long	L	Biot.
17	1626	7	9	13:20	N	E	N			$\frac{1}{2}$ M	15	Z	Arago II, 570
18	1648	1	8	4:	D	12 E	42 N				15		Chladni p. 100
19	1664	8	3	-	-	17 E	47 N			Br	?	C	Wien. Ak.,Sb.37,808,1859: Biot.
20	1676	3	31	-	-					F	1-2	A	Chladni p. 105
21	1683	8	12	9:	N	12 E	51 N			Br	15	Z ±?	W. & R. "Metcon", 12,X,21,1733
22	1686	7	19	13:30	N	12 E	52 N			$\frac{1}{2}$ M	7	Z	Greg., C.R. 73,514,1873
23	1688	4	17	2:30	D	9 E	49 N			F	15	M	Chladni p. 105
24	1719	3	19	8:08	N	4 W	51 N	295	+45	<S	1 +	Z	Phil. Tr. 30,978, 1719
25	1729	4	19	7:	T	6 E	46 N			-	75		Jahr. A. & G. 12, 1901
26	1729	6	2	-	-	8 E	47 N			F	66	M	Chladni p. 109
27	1738	7	13	11:	N	2 E	46 N			$\frac{1}{4}$ M	30	M	Chladni p. 112
28	1741	12	11	1:00	D	2 W	50 N			M	20+	135° ?	Phil. Tr. 42, 138, 1742; K 1 d
29	1743	10	15	9:30	N	0	52 N			F	20+	D,K	Quetelet Cat.; Am. Jour. Sci. 40,363,1841
30	1745	7	14	8:	T	1 W	52 N			F	61	D,C,P	Phil. Tr. 43,522,1745
31	1746	3	7	20:	D	7 E	51 N			F	30	L	Chladni p. 115
32	1750	6	7	7:	D	1 E	53 N			F	?	L	Greg.
33	1751	5	26	6:50	D	16 E	46 N	60	+ 20	B	4 h±	S,P	H.C. 166; K2d; iron
34	1753	12	4	3:	D	0	48 N			B	4-5		Chladni p.116
35	1755	11	27	9:	N	16 E	62 N			M	Long		Greg.
36	1756	1	2	7:	N	6 W	55 N			F,B	16		Greg.; Jahr. A. & G. 12, 1901 (possibly 1755)
37	1761	2	7	8:30	N	2 W	50 N			F	5	M	B.A.A.S. 33,210,1864, and 36,414,1867
38	1761	11	3	6:	N	1 W	51 N			F	15		Greg.
39	1762	11	12	16:45	N	5 E	43 N			B	?		Greg.; Jahr. A. & G., 14,903 gives 1761-11-12; Meteorite
40	1762	12	5	8:45	N	4 W	50 N			M	Sev. ?	C,S	Greg.; E.M., 79,264,1904
41	1763	4	29	2:45	D	2 E	49 N			F	14	K	Greg.; Sirius 34,12,1901; B.A.A.S. 33,210,1864
42	1768	12	22	19:	T	S.Atlantic				B	2	L	B.A.A.S.36,414,1867; Pogg.An.129, 174 (Sirius 24,11,1891 and (34,12,1901; A. N. 3030
43	1771	6	3	9:	T	2 E	49 N			X	30	D,K	
44	1778	2	-	10:	N	13 E	53 N			M	Long ?	M	Chladni p. 127
45	1779	10	31	6:10	T	83 W	37 N	306	+ 37	F	15	S	Tr. Am. Phil. Soc., 2,173,1786; Olivier notes
46	1783	9	26	-	N	1 W	51 N			Br	3"		B.A.A.S. 41,110,1872
47	1783	10	4	6:43	N	0	51 N			F	$1\frac{1}{2}$		Phil. Tr. 74,114 and 219,1784
48	1783	10	17	21:15	D	0	50 N			<M,B	1		B.A.A.S. 29,60,1860
49	1786	9	2	-	-	2 W	51 N				40	B	Greg.
50	1791	11	11	18:39	N	10 E	52 N			F	<1?	S,C	Wien Ak., Sb. 37,808,1859; B.A.A.S. 29,16, 1860
51	1793	9	10			2 W	55 N			> -2	5		Greg.
52	1794	6	16	7 +	D	11 E	43 N				60+	L	Chladni p. 133, stones
53		6	27	15:55	T	1 W	51 N				3 +	Y,B,P	B.A.A.S. 41,110,1872
54	1798	7	28	2:30	D	0	53 N			F,B	30	L	Greg.; Jahr. A. & G. 12, 901
55		10	8	16:24	N	12 E	51 N				1±	D,C,P	"Die Sternschnuppen" p.348,1839
56	1803	10	10	8:06	N	14 W	38 N			Br B	60	Y	Wien Ak. 62 II, 863,1870

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α δ ° °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
57	1805	10	23	7:30	N	7 E	53 N		F	20	D,C,S	(Phys. Worterbuck 4,220,1827; (H.C.,406;Kl;Gilbert Ann.23,106
58	1810	1	2	12:30	N	6 E	46 N		F	15	S	Greg.; Jahr. A.& G. 12, 1901
59	1811	5	15	8:35	T	3 E	47 N		F	10	S,E	Phil. Mag. 64,118,1824
60	1812	8	9	-	-	1 W	47 N		-	?	L	Jahr. A. & G. 12, 1901
61		8	23	9:	N	5 E	52 N		F	15		Chladni p. 154
62	1813	11	10	6:40	N	1 W	55 N		X	6	Y	Chladni p. 156; Ann. of Philos. 2,456,1813
63	1814	9	5	0:	D	1 E	44 N		F	Long	D,L,L	Ann. de Chemie. 9,28,1814; Stone
64		10	18 ?	10:	N	12 E	51 N		-	Many		(Jahr.A.& G.12,1901 (possibly Oct. 14, Greg.) Wien Ak.,37,811,1859
65	1815	5	10	10:30	N ?				F	Sev.	R	Chladni p. 158
66		7	2	P.M.	-	12 E	51 N		-	26	K	Sirius 34,11,1901
67	1817	4	10	10:		14 E	50 N		B	1+		Chladni p. 161
68	1818	2	15	6:30	N	1 E	45 N		B	30	D,L	B.S.A.F. 12,268,1904
69		8	3	11:15	N	0	51 N		F	1	Z,K	Sirius 34,12,1901; Greg.
70		10	31	8:30	N ?	26 E	45 N		F	5		B.A.A.S. 30,66,1860; aerolite
71	1819	5	5	0:30	D	2 E	57 N		B	Long	L	Greg.; Phil.Mag. 54,75,1819
72		11	13	-	-	72 W	19 N		F	18		Greg.
73	1821	6	15	3:00	D	5 E	44 N		B	15	Z	C.R. 89,918,1879; K 3d; stone
74		9	20	15:43	N	31 E	29 N		F	2		Pog. Annalen 612,1874; B.A.A.S. 43,190,1874
75	1822	3	9	10:00	N	77 W	42 N	257 + 40	B,M	10	C	Am.Jour.Sci. 6,318,1823; Phil. Mag. 64,118,1824; H.C. 86
76		3	16	10:05	N	78 W	37 N		F,B	Sev.		Arago. II, 570, Phil. Mag. 59,399,1822
77		6	3	8:15	T	0	47 N		F	15	D,S	Gil.Annalen 71,345,1822; K 4 d; stone
78		8	6	-	-	0	50 N		F	5	S	Phil. Mag. 64,119,1824
79		8	11	-	-	8 E	47 N		F	3		Greg.
80		9	1	-	-	77 W	18 N		F,B	Sev.		Greg.
81		11	15	7:58	N	10 E	54 N		B	1 +	Y	A.N. 1, 449, 1823
82	1823	8	7	4:30	D	70 W	44 N		Br	?	B	Am.Jour.Sci. 7,170,1823; stone
83		11	9	6:45	N	14 E	50 N		x	2 -	D,K	A. N. 1,468,1824
84	1825	11	14	-	-	3 W	56 N			2	K	Greg.
85		11	22	-	N	88 E	25 N		F	2.5	K	B.A.A.S. 19,120,1850
86		12	2	-	-	88 E	25 N		Br	5		B.A.A.S. 20,43, 1851
87	1826	3	31	9:	N	73 W	41 N		B	1		Am. Jour. Sci. 11,184, 1826
88	1827	12	11	-		8 E	49 N			75	K	V.Boguslawski; Sirius 34,12,1901
89	29	9	26	11:48	N	7 E	51 N		F	13	K,C	A. N. 8, 15+ 159,1831
90	31	11	12	16:00	N	5 E	47 N	Leonid	F	6		Quetelet 39,1839; Nat.53,7,1895
91	32	10	20	10:	N	3 W	52 N	Orionid ?	1	Sev ?	Y	B.A.A.S. 21,182,1852
92	33	11	12	-	N	74 W	41 N	Leonid	?	15	C	Trans. Am. Phi. Soc. N.S. 7,271
93		11	12	15:00	N	80 W	36 N	Leonid	>M	30 ±	S,D,P	Am. Jour. Sci. 25,378,1834
94		11	12	-	N	77 W	38 N	Leonid ??	?	10		Am. Jour. Sci. 25,390,1834
95		11	12	16:00	N	81 W	41 N	Leonid ??	F	75	C,D	Am. Jour. Sci. 25,391,1834
96		11	12	-	N	77 W	38 N	Leonid ??	?	2.3		Am. Jour. Sci. 25,390,1834
97		11	12	16: ?	N	80 W	40 N	Leonid ??	F	15 -	L,D	Am. Jour. Sci. 25,391,1834
98		11	12	17: ?	N	80 W	40 N	Leonid ??	?		1	Am. Jour. Sci. 25,391,1874
99		11	12	17:15	N	78 W	43 N	Leonid ??	F	3	C	Am. Jour. Sci. 26,338,1834
100		11	12	17:30	N	77 W	39 N	Leonid	?	4	L,S	Am. Jour. Sci. 25,375,1834
101 a		11	12	17:40	N	81 W	39 N	Leonid ?	- 5	15	C	Am. Jour. Sci. 26,87, 1834) same
101 b		11	12	-	N	83 W	40 N			10	D	Am. Jour. Sci. 26,338,1834)meteor?
102		11	12	17:45	N	73 W	41 N	Leonid	B	15 -	S,D	Am. Jour. Sci. 26,156,1834
103		12	8	-	N	12 E	52 N			?	L,P	"Die Sternschnuppen" 348,1839
104	1834	7	4	9:15	T	0	52 N		F	60 +		B.A.A.S. 21,183,1852
105		9	29	7:15	T	0	53 N		F	2.5	C,P	B.A.A.S. 21,183,1852
106	1835	11	14	-	-	18 E	34 S		-	20		Jahr. A. & G. 12, 1901
107		12	12	12:	N	12 E	52 N		Br	2		Greg.
108	1836	8	20	4:	D	90 W	40 N		¼ M,B	15	L	Am. Jour. Sci. 33,402,1838
109		11	14	—	-	24 E	38 N		-	5	K	Sirius 34,12, 1901
110		11	14	-	-	12 E	47 N		-	5		Jahr. A. & G. 12, 1901
111	1837	8	5	7:30	T	73 W	41 N		S,B	Sev.		Am. Jour. Sci. 33,200,1838
112	1838	1	2	7:	N	17 E	51 N		Br	2		Greg; meteorite
113		3	17			0	53 N		Br	10	K	Greg.

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
114		8	18			9 E	49 N			4		Greg.
115		11	13	17:	N	73 W	41 N	Leonid	B	9	D,E	Am. Jour. Sci. 35,369,1839
116		11	-	7:30	N	78 E	8 N		M	20 +	C,L,Z	B.A.A.S. 20,43,1851
117	1839	8	7			42 W	44 N		F	1		Greg.
118		8	26	9:	N	20 E	41 N		Br	20	S	Am. Jour. Sci. 39,381,1840
119	1840	1	8	7:50	N	10 E	54 N		B, $\frac{1}{2}$M	1	K	A. N. 18,54,1841
120		5	12	15:	N	72 W	41 N		B,M	4 -		Am. Jour. Sci. 39,382,1840
121		7	30	-	-	16 E	48 N		B	15	C	Wien Ak. 37,811,1859
122		8	10	-	-	6 E	51 N		-	1.5		Jahr. A. & G. 12, 1901
123	1841	3	8	-	-	3 E	40 N		B	2		Greg.
124		8	10	-	-	6 E	51 N			1.5		Wien AK. 37,811,1859
125		9	8	9:53	N	2 E	47 N		B	1.2		C.R. 13,637,1841
126		12	5	6:45	N	17 E	50 N		B,M	1		Greg.
127	1842	4	10	16:00	N	81 E	24 N		F	8 +	D,C	B.A.A.S. 19,121,1850; 21,238
128		7	11	9:10	N	0	50 N		F	3.5	D,R	C.R. 15,127,1842
129		8	5	8:20	T	17 E	51 N		B	Long	D,L	Greg.
130		11	11	14:34	N	10 E	45 N		- 5,B	1.5	Y	Met.Mag.1,325,1842-3
131	1843	3	7	8:48	N	10 E	52 N		F	1 +		A.N. 20,315,1843
132		6	21	-		3 E	40 N		M	1		Greg.
133		11	10	5:	D	20 E	45 N		X	4 -	L,M	B.A.A.S. 17,5,1848 (possibly Nov. 12); meteorite
134	1844	9	3	16:00	T	75 E	20 N		F	20	D	B.A.A.S. 21,238,1852
135		9	10	-		4 E	51 N		F	2		Greg.
136	1845	6	18	8:	T	31 E	37 N		>M	30+	D,L	B.A.A.S. 39,30,1861; K 6 d
137		7	2	14:	T	12 E	51 N		F	26	C,M	Sirius 34,12,1901; Wochen 2,226,1859
138		10	24	12:00	N	7 E	51 N		- 4	5- *	D,C,S	(Schmidt..'10 Years..', 93,1852 (Wien Ak. 56, II, 503,1867; K 2 (B.A.A.S. 29,16,1860
139	1846	6	20	8:30	T	4 E	37 N		Br	1		Greg.
140		6	21	9:30	N	9 E	49 N		-4,B	15		Wien Ak. Sb. 56,II,504,1867
141		8	24	10:30	N	1 E	45 N		Br	4 -		Greg.
142		9	25	10:	N	0	53 N		- 5	?	S	Phil.Mag.30,4;31,368 and Ap.4
143		10	17	6:15	T	9 E	50 N		- 3,	8		C.R. 46,985,1858
144		10	24	6:45	N	17 E	51 N		B	2	L	Greg.
145		11	9	7:30	N	5 E	47 N		Br,B	15	L,L	C.R. 23,985,1846
146		11	11			71 W	42 N		M,B	5		Greg.
147		11	19	P.M.	N	1 W	49 N		>- 2	20	Z	C.R. 23,986,1846
148	1847	1	10	5:00	T	16 E	48 N		$\frac{1}{2}$ M	10	S,M,P	Wien Ak.35,384; 37,811,1859
149		5	26	-		1 W	52 N		-	12		Greg.
150		7	13	15:45	T	13 E	52 N		F,B	Some	L,M	Pogg. Annalin 72,170,1847; iron
151		8	10	-		2 E	49 N		Br	9	L	Greg.; Jahr. A. & G. 12, 1901 (possibly Aug. 9)
152		8	11	9:53	N	7 E	53 N		Br	1.5 +	C	Wochen 1,356,1847 Wien Ak. 37,811,1859
153		10	30	7:	T	73 E	19 N		Br,B	15 ?		
154		11	11	-		83 E	21 N		B	10		Greg. (possibly Nov. 10;); Wien Ak. 37,872,1859
155		11	20	-		1 W	52 N		Br	7 +	Y	Greg.
156		12	8	11:11	N	6 E	51 N	Geminid	1	2 -	E	Heis '43 Years, etc.' 4, No. 84
157		12	11	8:30	N	70 W	45 N		$\frac{2}{3}$ M	1	Z	Smithsonian Rep. 324,1857
158	1848	1	20	-		74 W	41 N		F	12		Greg.
159		3	29	-		17 E	48 N		M	30	C,L	Greg.
160		9	4	8:59	N	0	50 N		<M,B	3-	Z	B.A.A.S. 18,14,1849; C.R. 73,513,1871
161	1849	8	9	9:	N	3 E	40 N	Perseid ?	-5	7		B.A.A.S. 20,4 + 38,1851
162		8	25	10:	N	2 W	53 N		-5	Long		B.A.A.S. 19,104,1850
163		11	5	6:20	N	1 W	53 N	64 + 18	-3	5	S,P	(B.A.A.S. 19,94 + 104, + 106, (1850; HC 427; Phil.Mag.36,381, (1850
164		11	7	-		74 E	18 N		B	2		Greg.
165		11	12	16:	N	12 E	54 N		F,B	15		Greg; Jahr. A. & G. 12, 1901
166		11	13	-	-	15 E	32 N		B	90		Proc.Am.Phi.Soc. 17,340,1878; stones
167		12	4	11:40	N	1 W	53 N		-5	8		Greg.
168		12	19	5:10	N	1 W	53 N		-5	2.5		B.A.A.S. 19,94,1950

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α	δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	°	°				
169	1850	1	1	15:45	N	6 E	51 N			M,B	2 -		B.A.A.S. 29,102,1860; C.R. 73,513,1871
170		2	5	6:50	N	1 E	51 N			½M,B	3 +	Z	B.A.A.S. 20,6,1851
171		2	11	10:45	N	2 W	55 N			B	5		Phil. Mag. 36,221 + 249,1850;
172		2	13	9:35	N	1 W	53 N			½M	1.5		Greg.
173		6	5	9:15	T	5 E	49 N			< M B	Sev.		A.N. 35,285,1853
174		7	28	-		8 E	52 N			F	10		Greg.
175		9	30	8:54	N	71 W	42 N			B	75°	C,D,S	B.A.A.S. 24,95,1855
176		11	6	7:00	N	73 E	18 N			B	20°	K	B.A.A.S. 20,44,1851: 19,238, 1852
177	1851	4	17	8:	N	7 E	51 N			M,B	3		Wien Ak.37,804,1859: stone
178		4	20	10:	N	80 E	26 N	Lyrid ?			1 +		B.A.A.S. 20,51,1851
179		5	2	10:	N	80 E	13 N	Sp.		X	1 +		B.A.A.S. 21,228,1852
180		5	22	10:15	N	80 E	13 N			Br	2	Y	B.A.A.S. 21,228,1852
181		6	20	11:30	N	2 W	51 N			F	3.5	Z ??	B.A.A.S. 20,36,1851
182		6	22	9:30	T	6 W	55 N			M.B	10	E,Y,D	B.A.A.S. 20,36,1851
183		11	5	5:30	T	5 W	40 N			B,½M	20	L	B.A.A.S. 21,202,1852: stones
184	1852	8	12	-		3 W	51 N			M	2	Z	Greg.
185		10	5	9:15	N	5 E	50 N			Br	Long		B.A.A.S. 36,417,1867: 21,212,1852 Cosmos, Dec. 1852
186		11	24	-		2 E	49 N			F,B	5		Greg.
187	1853	8	9	-	-	17 E	50 N			-	30		Jahr. A. & G. 12, 1901
188		8	26	-		17 E	53 N			Br	10		Greg.
189		9	12	-		5 E	46 N			-5	6		Greg.
190		10	26	14:	N	17 E	53 N			-4	10	S	Wien Ak. Sb. 37,809,1859;
191		10	28	3:57	D	0	53 N	261	+49	½S	5	E	B.A.A.S. 23,414,1854; H.C. 416
192		12	11	9	N	12 E	51 N			Br	15	K	Sirius 34,11,1901
193	1854	4	1			14 E	52 N				3		Wien Ak. 37,812, 1859
194		8	1	12:34	N	10 E	52 N	Perseid		Br, B	8 3 °	D,S,P	Wien Ak.37,809,1859; Heis 61;K3
195		8	1	14:04	N	10 E	52 N	Perseid		Br	2.5 °	D,S	Heis 61;K4,A.N.39,116 + 118,1855
196		10	17	-		10 E	54 N			B	Long		Jahr. A. & G. 12, 1901
197		11	16	23:	D	7 E	53 N			F,B	Long		Wien Ak. 37,811,1859; Greg.
198	1855	1	7	4:45	T	0	53 N	Quad. ?		Br	15 -	D,C,E,P	B.A.A.S. 25,61, 1856
199		12	10	-	-	13 E	56 N			-	15		Jahr. A. & G. 12, 1901
200		12	18	18:13	N	0	53 N			S	10	D,R,P	B.A.A.S. 25,61,1856
201	1856	1	7	4:52	T	1 W	51 N	350	+33	< M	18	D,C	(B.A.A.S. 25,54 + 60,1856; (134 - 140,1857; H.C. 6; K7d (M.N. 16,161,1856
202		7	8	6:	D	87 W	33 N	157	+ 15	Br, B	15	S	Am.Jour.Sci. 11,22,248 + 23,287 H.C. 214
203		7	30	9:48	N	2 E	49 N			Br	4	Z	C.R. 43,257,1856
204		8	10	9:07	T	0	53 N	Perseid ??		-3	1		B.A.A.S. 27,140,1858
205		10	29	6:15	N	14 E	46 N			½ M	30	D,C	Unterh. Astr. 375,1856; Greg.
206	1857	4	11	9:	N	94 W	46 N			> M	10	Y	Greg.
207		7	20	-		0	52 N				5	M	Greg.
208		11	23	11:38	N	0	53 N			-3	5	Y	B.A.A.S. 27,148,1858
209	1858	7	11	11:10	N	11 E	54 N			5-	3-		Wochen. 1,297,1858
210		8	9	11:59	N	140 E	36 N	Perseid ??		B	1	Z	B.A.A.S. 34,60,1865;36,417,1867
211		8	12	-		2 E	49 N			-5,B	3		Greg.
212		8	26	8:45	N	13 E	50 N			-4	1	Y	Wochen. 2,221,1859
213		9	10	10:20	N	7 E	50 N			½ M	Long	B,B	Wochen. 1,415,1858
214		11	12	14:45	N	7 E	51 N			B	10 -	K,Z,S	Wochen. 2,225,1859
215		12	5	5:	T	50 E	13 N			Br	15	D,E,P	B.A.A.S 28,86 + 91, 1859
216		8	9	14:56	T	24 E	38 N	Perseid		0	3.7°	D,P	Wien Ak. 56, II, 509, 1867
217	1859	8	9	15:56	T	24 E	38 N				2.8°	M,P	Wien Ak. 37, 810, 1859
218		8	9			24 E	38 N				2.3		Wien Ak. 37, 812, 1859
219		8	10	19:20	D	74 W	43 N			Br	Long	L,Z	Am. Jour. Sci. II 28,300,1859
220		8	17			12 E	51 N			Br	Long		Greg.
221		8	20	6:40	D	118 E	24 N			Br	10	S	B.A.A.S. 33, 210, 1864
222		10	18	9:37	N	24 E	38 N			-2	6 °		Wien Ak. 56 II, 509, 1867
223		10	27	9:32	N	24 E	38 N			-3	5+ °	M,P,S	(Wien Ak.44,II,227,1862; Schmidt (227,Wien Ak. 56, II, 509, 1867
224		11	8	17:30	N	0	53 N			Br	10	L,E	B.A.A.S. 29, 8, 1860
225		11	14	21:30	D	75 W	39 N	243	+ 30	S,B	2	D,S	Am.Jour.Sci. 29,137+ 298;30,186 H.C. 454

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α °	δ °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
226	1860	1	24	5:05	T	6 E	51 N			-4	15	S,B	Wochen. 4,61,1861
227		2	23	9:46	N	24 E	38 N			-3	1.7		Wien Ak. 56, II, 510, 1867
228		8	9	10:35	N	24 E	38 N			1	2 *	C,P,D	Wien Ak. 44, II, 227, 1861
229		8	10	15:10	N	24 E	38 N	Perseid		-3	1+*	D,P	Wien Ak. 44. II, 227, 1861; 56, II, 510, 1857
230	1861	3	3	21:30	D	144 E	38 S			½M,B	20		B.A.A.S., 35,127,1866+36,419, 1867
231		5	17	14:	N	145 E	38 S			>-3	1		Wochen. 13,346,1870
232		7	16	11:30	N	0	51 N	32	+ 23	M	5	D,C	B.A.A.S. 31,10,1861: 5+77,1862; H.C. 224: K5
233		7	25	11:02	N	13 E	53 N			M	23		Sirius 29,9,1901
234		7	29	-	-	22 E	39 N			-	3		Jahr. A. & G. 12, 1901
235		8	9	13:38	N	24 E	38 N	Perseid		-1	3 *	D,P	Wien Ak.44, II, 227, 1861
236		8	10	9:20	N	3 W	43 N	Perseid??		Br	4	Y	B.A.A.S. 30,16,1861
237		8	12	12:25	N	24 E	38 N	Perseid		-1	1 *	Z	Wien Ak.44, 11, 228,1861
238		10	4		?	73 W	41 N			F	2	S	B.A.A.S. 36,419,1867
239		11	15	10:30	N	91 W	42 N			F,B	Sev.		B.A.A.S. 46,102,1877
240	1862	1	9	11:30	N	14 E	50 N			<M	10	A	Wochen.15,136,1862
241		2	7	5: ?	T	17 E	49 N			F	10		B.A.A.S. 36,420,1867
242		4	23	10:03	N	24 E	38 N			M	30 *		Wien Ak 56, 11, 511, 1867: B.A.A.S. 36,421,1867
243		4	25	8:20	N	147 E	43 S	Sp.		>M	10	D	B.A.A.S. 36,291 + 374,1867
244		7	28	2: ?	D	9 E	46 N			F	15		B.A.A.S. 36,421,1867
245		9	19	10:14	N	0	51 N	22	+16	M	11	Z,S	B.A.A.S. 31,73,1862: HC 353: Proc. B.M.S.1,263,1862
246		9	27	-	-	14 E	41 N			-	Many		Jahr. A. & G. 12, 1901
247		10	26	7:45	N	3 W	52 N	Sp.		Br	3	D,C	B.A.A.S. 32,226,1863
248	1863	7	19	8:12	T	2 W	52 N	310	-12	B	23	S	B.A.A.S. 32,262,1863; H.C. 229
249		8	9	9:48	N	8 E	52 N	Sp.		1	2.2 *		B.A.A.S. 32,331,1863: Heis 99
250		8	10	9:30	N	13 E	45 N	27	+52	½M	4	S	B.A.A.S. 33,274,1864; 33,90,1864
251		8	10	9:24	N	0	51 N	Perseid		-4	4.5 *	S	B.A.A.S. 32,276,1864
252		8	10	9:31	N	8 E	52 N	Perseid		-4	0.9 *		B.A.A.S. 33,331,1864; Heis 101, Wochen.6,259,1863
253		8	10	9:45	N	12 E	46 N	Perseid		M ?	10	D,S	Wien Ak. 48, II, 309, 1863
254		8	10	9:51	N	8 E	52 N			-3	0.4 *		B.A.A.S. 33,331,1863
255		8	10	10:38	N	8 E	52 N	Sp.		1	1.3 *	S	B.A.A.S. 32,331,1864, Heis 102
256		8	10	10:46	N	0	51 N	Perseid ?		-5	4.5 *	R,P	B.A.A.S. 33,296 + 333,1864
257		8	10	11:08	*	8 E	52 N			-3	0.7 *		B.A.A.S. 33,331,1864
258		8	10	12:12	N	8 E	52 N	Perseid		1	2.8 *	R,L	B.A.A.S. 33,331,1864; Wochen. 6,323,1863
259		8	10	12:39	N	20 E	50 N	Perseid		Br	5	C,B,B	Wochen. 6,373,1863
260		8	10	12:52	N	8 E	52 N	Perseid		-3	1 *	C,D	B.A.A.S. 33,331,1864; Wochen. 6,259,1863
261		8	10			24 E	38 N				13		Jahr. A. & G. 12, 1901
262		8	10			20 E	50 N				Many		Jahr. A. & G. 12, 1901
263		8	21	10:35	N	24 E	38 N			M	5 *	Z	Wien Ak. 56, II, 512, 1867; Wochen. 6, 316, 1863
264		9	12	8:40	N	24 E	38 N	Perseid.		-3	90 *	D	Wien Ak. 56, II, 512, 1867; Wochen. 6,316,1863
265		10	15	10:00	N	1 W	53 N	80	+23	-4	10	K	B.A.A.S. 33,8: H.C. 393
266		10	18	14:55	N	24 E	38 N	102	-29	Br	10 *	D,R,P	Wien Ak. 48, II, 551,1863; 56, II,512,1867;Wochen.6,375,1863
267		11	6	5:42	N	24 E	38 N			-3	7 *		Wien Ak. 56, II, 513, 1867
268		11	13	13:32	N	24 E	38 N			-3	5 *		Wien Ak. 56, II, 513, 1867
269		11	13	13:38	N	24 E	38 N			-4	5 *		Wien Ak. 56, II, 513, 1867
270	1863	11	13	14:02	N	24 E	38 N			-3	8 *		Wien Ak. 56, II, 513, 1867
271		11	13	15:05	N	24 E	38 N			-3	30 *		Wien Ak. 56, II, 513, 1867
272		11	13	15:38	N	24 E	38 N			-4	25 *		Wien Ak. 56, II, 513, 1867
273		11	13	16:47	N	24 E	38 N			-4	9 *		Wien Ak. 56, II, 513, 1867
274	1864	2	22	9:	N	38 E	58 N			F	Long	Y	B.A.A.S. 36,425, 1867
275		5	14	8:00	T	2 E	44 N	86	+24	M+	30	Y	B.A.A.S. 33,45,1864; H.C.155;C.R. 58,1066,Bruun 15,143,1879;stones
276		7	29	11:23	N	22 E	39 N			-3	3 *		Wien Ak. 56, II, 514, 1867
277		8	2	8:30	N	22 E	39 N			-3	3 *		Wien Ak. 56, II, 514, 1867
278		8	2	12:30	N	22 E	39 N			-4	10.1 *		Wien Ak. 56, II, 514, 1867

NO.	DATE Y	M	D	HOUR	TYPE	λ φ	RADIANT α δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						° °	° °				
279	1864	8	10	6:41	D	24 E 38 N	132 + 22	Br	16 *	L	Wien Ak. 50, II, 455, 1864; H.C. 280
280		8	15	12:40	N	9 E 47 N		F	Sev.	M	B.A.A.S. 34, 62, 1865; Astr. Reg. 3 11, 1865
281		8	22	9:08	N	22 E 39 N		-4	9 *		Wien Ak. 56, II, 499, 1867
282		9	8	3:	D	14 E 37 N		B	60		B.A.A.S. 36, 427, 1867
283		9	20	16:04	N	22 E 38 N		Br	10		Wien Ak. 56, II, 514, 1867
284		9	24	0:20	D	4 E 44 N	334 + 50	B	Sev.	D, R	C.R. 59, 573, 605, 1864; H.C. 360; B.A.A.S. 36, 427, 1867
285		11	11	5:36	T	2 E 44 N	55 + 21	>M	5	E	C.R. 59, 831, 1864: H.C. 434; B.A.A.S. 49, 44, 1880
286	1865	2	15	6:	N	8 E 51 N	279 + 60	- 4	15	S, G	Wochen. 8, 79, 95, 1865; H.C. 60
287		2	17	5:30	T	5 E 51 N		- 4	10		Wochen. 9, 367, 1866; B.A.A.S. 34, 88, 1865
288		7	25	11:12	N	24 E 38 N		- 4	10 *		Wien Ak. 56, II, 515, 1867
289		7	27	11:09	N	24 E 38 N		- 4	21 *		Wien Ak. 56, II, 515, 1867
290		10	18	14:54	N	24 E 38 N		- 4	16 *		Wien Ak. 56, II, 516, 1867
291		11	12	16:00	N	73 W 41 N	Leonid ?	Br, B	1 +	D, C	Am. Jour. Sci. II, 41, 58, 1866; K1
292		11	12	16:00	N	73 W 41 N	Leonid ?	Br	Sev. ?	D	Am. Jour. Sci. II, 41, 58, 1866; K2
293		11	12	17:07	N	0 53 N	Leonid	2/3 M	1.	Y	B.A.A.S. 35, 58, 1866: 36, 429, 1867
294		11	13	12:48	N	4 E 52 N	Leonid ?	Br	36 *	D, P	Pop. Sci. Mon. 79, 191, 1911 etc.; K6
295		12	24	17:30	N	10 E 54 N		Br, B	3	Z	Wochen. 9, 8, 1866
296	1866	1	12	14:48	N	8 E 45 N		Br	6	D, B, E	Bol. Met. Oss. Torino Jan. 1866
297		6	9	4:55	D	14 E 49 N	170 + 55	B	30+	L, P	Wien Ak. 54, II, 200, 1866; H.C. 189; stones
298		6	19	23:00	D	2 E 47 N	200 + 54	½M, B	15	Y	B.A.A.S. 35, 104 + 128, 1866; 36, 430, 1867; H.C. 202
299		7	17	9:20	T	10 E 60 N		1/3 M	12	D, S, P	Backhouse letter; B.A.A.S. 36, 430, 1867
300		8	9	11:48	N	24 E 38 N		- 4	10.1*		Wien Ak. 56, II, 517, 1867
301		10	18	15:	N	1 E 51 N	Orionid	F	5	C	B.A.A.S. 36, 294 + 382, 1867
302		11	12	12:30	N	3 W 51 N	Leonid ?	F	45	M, L, S	B.A.A.S. 42, 370, 1873
303		11	12	14:14	N	0 53 N	Leonid	-	15	D	Obs. 20. 273. 1897: K 7
304		11	13	p.m.	N ?	75 E 19 N		-	5	D	Am. Jour. Sci. TT, 43, 276, 1867 (twilight?) K8d
305		11	13	-	N	13 E 53 N	Leonid ??	Br	Sev.	M	Sirius 18, 225-9, 1890
306		11	13	12:10	N	0 52 N		Br	12		B.A.A.S. 36, 306, 1867
307		11	13	-	N	0 52 N		?	0.6 *	C, P	B.A.A.S. 36, 405, 1867
308		11	13	-	N	0 52 N		?	0.7 *	S, P	B.A.A.S. 36, 405, 1867
309		11	13	12:33	N	4 W 56 N	Leonid	-3	5	D, C	B.A.A.S. 36, 306, 1867; K 8
310		11	13	12:40	N	4 W 56 N	Leonid	-5	8.2	D, C	B.A.A.S. 36, 306+372, 1867; Phil. Mag. 33, 83, 1867; K9
311		11	13	13:07	N	0 52 N	Leonid	Br	10 *	D, C	B.A.A.S. 36, 308, 1867: K 10
312		11	13	13:08	N	3 W 52 N	Leonid	-4	14	D, S, P	B.A.A.S. 36, 308, 313 and Ap. 1867; K 11
313		11	13	13:12	N	2 W 51 N	Leonid	Br	6	D, L	Denning letter; B.A.A.S. 36, 310, 1867
314		11	13	13:20	N	0 51 N		-5	2		B.A.A.S. 36, 310, 1867
315		11	13	13:28	N	3 W 51 N	Leonid ??	1/3 M	3 +	C, B	B.A.A.S. 36, 310, 1867; Met. Mag. 1, 93, 1866
316		11	13	13:30	N	24 E 38 N		-4	2		Wien Ak. 56, II, 499, 1857
317		11	13	13:45	N	0 51 N	Leonid	Br	3	Y	B.A.A.S. 36, 313, 1867
318a		11	13	13:24	N	0 52 N		-1 ?	4+	B	B.A.A.S. 36, 310, 1867) same
318b		11	13	13:00	N	6 W 53 N	Leonid ?	Br	11	C, R	Met. Mag. 1, 109, 1866) meteor?
319		11	13	13:50	N	2 W 51 N	Leonid	Br	9 *	D, C	B.A.A.S. 36, 406, 1867; K 12
320		11	13	14:10	N	1 E 51 N	Leonid	-4	4	M, B	B.A.A.S. 36, 312, 1867
321		11	13	14:11	N	73 W 42 N	Leonid	Br	9	D, C, E	Am. Jour. Sci. II, 43, 86, 1867; K 3
322a		11	13	14:12	N	1 W 53 N	Leonid	?	3	D	B.A.A.S. 36, 313, 1867 } same
322b		11	13	14:12	N	1 E 51 N	Leonid	-2	6	D, C, P	B.A.A.S. 36, 313, 1867) meteor ??
323a		11	13	14:14	N	4 W 56 N	Leonid	-4	5.8	D, L	B.A.A.S. 36, 314, 1867; K 14) same
323b		11	13	14:15	N	3 W 56 N	Leonid	Br	1	Y	B.A.A.S. 36, 314, 1867)meteor?
324a		11	13	14:16	N	0 51 N	Leonid	B, -3	1.5	Y	B.A.A.S. 36, 314, 1867; Gr. Obs 1866, 298 No. 54 } same
324b		11	13	14:16	N	2 W 52 N	Leonid	-5	2		B.A.A.S. 36, 404, 1867 } meteor?
325a		11	13	14:20	N	1 E 51 N	Leonid	-5	2.8	D?, Y	B.A.A.S. 36, 314, 1867 } same
325b		11	13	14:21	N	N	Leonid	-3	2		B.A.A.S. 36, 377, 1867 } meteor?
326		11	13	14:40-	N	3 W 56 N	Leonid	-5	15	D, P	B.A.A.S. 36, 373, 1867; etc., K 16

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						°	°	° °				
327		11	13	15:06	N	0	51 N	Leonid ???	Br	Many	S	B.A.A.S. 36,319 + 407,1867
328		11	13	15:47	N	2 W	55 N	Leonid		8		Denning: B.A.A.S. 36,370,1867 ?
329		11	13	16:18	N	24 E	38 N	Leonid	Br	51+	L,C	Wien Ak. 54, II, 775,779,1866; 56,II,502,1867
330		11	13	16:31	N	24 E	38 N		-3	7		Wien Ak. 56, II, 499,1867
331		11	13	16:56	N	24 E	38 N		-4	13		Wien Ak. 56, II, 499,1867
332		11	13	17:05	N	24 E	38 N		-3	7		Wien Ak. 56, II, 499,1867
333		11	13	18:40	N	1 W	54 N	Sp.	1	1.5		B.A.A.S. 36,318,1867
334	1867	6	11	8:11	T	2 E	46 N	86 + 44	<M	60 *	D,E,P,S	B.A.A.S. 36,378,1867; H.C. 195; C.R. 64,1304: K 9 d
335		7	4	11:58	N	24 E	38 N		-4	5 *		Wien Ak. 56, II, 520,1867
336		8	10	14:04	N	11 E	45 N	Sp ?	-3	3	M,P	B.A.A.S. 37,348,1868 Met. Ital. Sup. 1867
337		8	10	14:23	N	24 E	38 N		-2	4 *		Wien Ak. 56, II, 521, 1867
338		8	10	14:51	N	24 E	38 N		-3	10 *		Wien Ak. 56, II, 521, 1867
339		8	11	-	-	15 E	50 N		-	5		Jahr. A. & G. 12, 1901
340		10	3	10:30	N	7 E	51 N		Br	8	S,B	Wochen. 10,373,1867
341		11	13	13:57	N	72 W	44 N	Leonid	-5	6	C	Am. Jour. Sci. 2,45,255,1868; K4
342		11	13	14:51	N	92 W	42 N	Leonid		4	D	Am. Jour. Sci. 2,45,227,1868; K5
343		11	13	14:56	N	92 W	42 N	Leonid		3	D	Am. Jour. Sci. 2,45,231,1868; P.A. 44, 562, 1936; K6
344		11	13	15:03	N	92 W	42 N	Leonid ?		2	D	Am. Jour. Sci. 2,45,231,1868; P.A. 44,562,1936; K7
345		11	13	15:08	N	92 W	42 N	Leonid ??		?	D,C	Am. Jour. Sci. 2,45,231,1868; P.A. 44,562,1936; K8
346		11	13	16:00	N	73 W	41 N			4	D	Am. Jour. Sci. 2,45,81,1868; K 10
347		11	13	16:01	N	92 W	42 N	Leonid ??		?	D	Am. Jour. Sci. 2,45,231,1868; P.A. 44,562,1936; K 9
348		11	13	16:07	N	77 W	39 N	Leonid ?		5	D,L	U.S.Naval Observatory; K 11
349		11	13	16:18	N	74 W	43 N	Leonid		1	B,Y	Proc. B.M.S. 4,67,1867
350		11	13	16:30	N	75 W	40 N	Leonid		3+	C	Proc. Am. Phil. Soc. 10, 357
351		11	13	17:01	N	74 W	43 N	Leonid ?	F	1	Y	Proc. B.M.S. 4,67,1868
352		11	13	17:01	N	74 W	43 N	Leonid ?	F	1	Y	Proc. B.M.S. 4,67,1868
353		11	13	17:07	N	74 W	43 N	Leonid ?	F	1.1	Y	Proc. B.M.S. 4,67,1868
354		11	13	17:41	N	74 W	43 N	Leonid ?	F	1.1	Y	Proc. B.M.S. 4,67,1868
355		11	14		N ?	4 E	51 N		-	1		Jahr. A. & G. 12, 1901
356		11	14	-	N ?	61 W	16 N		-	Some		Jahr. A. & G. 12, 1901
357		12	31	19:30	T	1 W	51 N	(348 + 33) ?	-4	40	D,S	B.A.A.S. 37, 356 - 390, 1868; H.C. 517; K 17
358	1868	6	5	23:40	D	97 W	39 N	69 + 24	>M,B	17	L	Am. Jour. Sci. 2,46,429,1868
359		6	14	10:30	N	8 E	52 N		F	3+	Y	Wochen. 11,227,1868
360		7	12	10:15	N	8 E	52 N		-4	2	Y	Wochen. 11,237,1868
361		8	10	12:25	N	2 W	53 N	Perseid	-4	0.5	D,S,R,P	B.A.A.S. 37,379,1868: K 18
362		9	5	8:15	N	8 E	47 N	14 -2	-2	2+	Y	C.R. 69,326,1869; H.C. 332 b
363		9	8	9:30	N	8 E	52 N		-	2+	M	Wochen. 11, 374, 1868
364		11	13	-	-	13 E	52 N		-	2		Jahr. A. & G. 12, 1901
365a		11	13	11:17	N	75 W	40 N	Leonid	Br	10	S	B.A.A.S. 38,291,1869)
365b		11	13	11:25	N	74 W	41 N	Leonid ?	- 5	8	C,P	Am.Jour.Sci.2,47,410,Aph.)same Jour. 26,107,1907)
366		11	13	11:34	N	75 W	40 N	Leonid	Br	7	S	B.A.A.S. 38,291,1869
367		11	13	12:20	N	4 W	40 N		X	Sev.	K	A. N. 72,354,1868
368		11	13	12:25	N	77 W	39 N	Leonid ?	- 3	10	Y,E	'Nov.Met. 1868', Eastman
369		11	13	12:30	N	77 W	39 N	Leonid ??	- 4	30	R	'Nov.Met. 1868', Eastman
370		11	13	13:16	N	74 W	41 N	Leonid	>- 3	44	D,S,P	Am.Jour.Sci.2,47,121 + 408, 1869; K 12
371		11	13	13:53	N	74 W	41 N	Leonid	Br	0.5 *	S	Am. Jour. Sci. 2,47,410,1869
372		11	13	14:33	N	4 W	40 N	Leonid	Br	10	R	B.A.A.S. 37,244,1868; A. N. 72,353,1868
373		11	13	14:45	N	74 W	41 N	Leonid ?	- 5	10	M	Am. Jour. Sci. 2,47,410,1869
374		11	13	14:46	N	0	52 N	Leonid	- 3	1+		Gr. Obs. 1868, 98 No. 4
375a		11	13	14:48	N	74 W	41 N	Leonid ?	Br	3	D,B	Am. Jour. Sci. 2,47,411,1869)
375b		11	13	15:00	N	76 W	42 N	Leonid	-	Sev.	D	Am. Jour. Sci. 2,47,125,1869) Possibly same meteor; K 13
376		11	13	15:50	N	12 E	42 N	Leonid	F	5	L,D,S	Wochen. 12,335,1869; Proc. B.M.S. 4,246,1868
377		11	13	15:52	N	73 W	43 N	Leonid	Br	3	D	Am.Jour.Sci. 2,47,411,1869; K 14

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
378	1868	11	13	16:16	N	12 E	42 N	Leonid ?	F	Long	Y	Proc. B.M.S. 4,247,1868
379		11	13	16:30	N	75 W	40 N	Leonid	-	Sev.		B.A.A.S. 38,291,1869
380		11	13	16:31	N	75 W	40 N	Leonid	-	Sev.		B.A.A.S. 38,291,1869
381		11	13	16:51	N	12 E	42 N	Leonid	F	10	C	Wochen. 12,335,1869
382		11	13	17:06	N	73 W	41 N	Leonid	Br	6	D	Am.Jour.Sci. 2,47,412,1869; K 15
383		11	13	17:25	N	86 W	39 N	Leonid ?	-	10	D	Am.Jour.Sci. 2,47,125,1869; K 16
384		11	13	17:30	N	71 W	42 N	Leonid	Br	7	D,B,S	Am.Jour.Sci. 2,47,413,1869; K 17
385		11	14	12:20	N	4 W	40 N		X	Sev.		B.A.A.S. 38,294,1869
386		11	14	13:30	N	39 W	13 S	Leonid ?	B	15	Z ?	B.A.A.S. 38,246,1869
387		12	1	7:14	N	8 E	52 N		-	Long	M	Wochen. 11,408,1868
388	1869	5	5	6:32	D	8 E	49 N		-	Long		Met. Mag. 4,151,1869; Stone
389		6	7	9:07	T	8 E	52 N	250 + 35	Br	23	D	Wochen. 12,191 & 198, 1869; H.C. 190; Stone Meteorite?
390		6	17	13:12	N	5 E	43 N		F	18	Y	L'Annee Sci. 14,15,1869
391		8	24	7:25	T	78 W	41 N		Br	30	D,R,P	B.A.A.S. 39,89,1870; M.W.R. Sept. 1907; K 10d & 11 d
392		9	7	9:50	N	6 E	46 N		Br,B	15 +	Y	Wochen. 12,328,1869
393		11	6	6:50	N	4 W	51 N	62 + 37	½M, B	50	D,S,P	B.A.A.S.39,79,1870:Nat.1,58-267,1869: K19 MN 309,1869:Proc.B.M.S.5,139,1870
394		11	13	13:15	N	87 W	30 N		F,B	50	D,C	Am.Jour.Sci.II 49,245,1870; K18
395		11	13	14:33	N	120 W	34 N	Leonid ?		8.5	D,R	M.N.30,67,1870;Am.Jour.Sci. 2, 49,245,1870
396		11	13	15:32	N	32 E	32 N	Leonid	Br,B	3 +	Z	M.N. 30,31,1869
397		11	13	15:40	N	32 E	32 N			5 +	D,S	M.N. 30,31,1869
398		11	14	14: ?	N	24 E	38 N	Leonid ?	F	15	L	Wochen. 13,101,1870
399		12	12	-	-	4 W	56 N		-	Long		Jahr. A. & G. 12, 1901
400	1870	2	26	9:43	N	2 E	49 N		-4,B			Wochen. 13, 128, 1870
401		8	6	10:05	N	5 W	55 N	Sp.		23	D,P	Backhouse letter
402		8	15	9:00	N	5 W	55 N	312 - 12	F,B	20	D,P	Backhouse letter; Nat. 2,357, 1870; H.C. 296; K 12 d
403		9	27	6:08	T	10 E	54 N	152 + 47	B	20	S,L	A.N. 77,321,1871; H.C. 370; meteorite ?
404		11	3	15:	N	78 E	27 N		F	5	B,E,S	B.A.A.S. 40,32,1871, Nat. 3, 209,1871
405		11	13	10:06	N	5 E	46 N		Br,B	4 +	Z ?	C.R. 73,154,1871
406		11	14	-	-	12 E	52 N		-	10		Jahr. A. & G. 12, 1901
407		12	12	5:30	T	14 E	36 N	106 + 32	Br	35	D,E	B.A.A.S. 43,296,1874; Denning
408	1871	2	13	9:04	N	3 W	51 N	118 - 3	M,B	10	P,C	B.A.A.S. 40,32,1871; H.C. 57; Bruun 47,41,1908
409		2	27	10:58	N	2 E	49 N		-	60 +		Wochen. 14, 239, 1871
410		3	17	10:49	N	0	46 N	345 + 50	B	60	Z ?,S,E	C.R. 72,328 + 383 + 1871; H.C. 97
411		4	22	10:37	N	9 E	45 N	231 - 7	- 3	3.5		B.A.A.S. 40,36,1871; H.C. 137
412		4	30	14:30	N	79 W	9 N		Br	2	Y	Nat. 4,149,1871
413		7	13	10:06	N	3 E	46 N		Br,B	5 -	Y	C.R. 73,154,1871
414		8	10	12:31	N	1 W	52 N	Perseid		30	S	B.A.A.S. 41,83,1871; 43,278 + 284; 1874; Denning
415		9	6	19:07	T	10 E	45 N		-5,B	2	Y	Pub. Brera 7,17
416		9	8	11:13	N	30 E	31 N		Br,B	3.3	C	Am. Jour. Sci. III 2,474,1873
417		9	14	7:32	N	18 E	48 N		F	2		Wochen. 14,411,1871
418		11	14	16:00	N	7 E	45 N	Sp. ?	- 3	4	S	Pub. Brera 7, 103
419		12	6	8:15	N	1 W	53 N	Sp.	-4,B	3	Y	B.A.A.S. 41,113,1872: H.C. 485
420		12	8	11:44	N	11 E	44 N	Sp.	>1;B	8		Pub. Brera 7, 108 (No. 8938)
421		-	22	8:15	N	99 W	20 N		B	10	Y	Am. Jour. Sci. III 3,235,1872
422	1872	5	15	14:45	N	100 W	15 N		Br,B	15 -	K,R	B.A.A.S. 43,368,1873
423		8	9	9:53	N	13 E	44 N	Perseid	M	2		Pub. Brera 7,53 (No. 4346)
424		8	11	10:10	N	13 E	44 N			60	Z ?,K	Pub. Brera 7,69
425		8	30	17:15	T	12 E	42 N	90 - 14 ?	Br	15	S	B.A.A.S. 44,250,1875; Wochen. 15,299,1872; stones
426		10	24	-	-	34 E	47 N		-	Long		Jahr. A. & G. 12, 1901
427		11	27	6:	T	22 E	39 N	Bielid ?	Br	8 +	Y	Met. Mag. 7, 2, 1872
428		11	27	6:35	N	9 E	45 N	Bielid ?	-	21	L,C	B.A.A.S. 42,390,1873
429		11	27	7:30	N	2 E	44 N		B	15		C. R. 75, 1553, 1872
430		11	27	7:55	N	1 W	53 N	Bielid	+ 2	2		Am. Jour. Sci. III 5,152,1873
431		11	27			8 E	52 N			10		Jahr. A. & G. 12, 1901
432		11	27			8 E	52 N			7		Jahr. A. & G. 12, 1901

NO.	DATE Y	M	D	HOUR	TYPE	λ φ (° °)	RADIANT α δ (° °)	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
433		11	27	11:22	N	58 E 20 S	Bielid ?	-	4	M	B.A.A.S. 42,392,1873; Nat.7,232, 1873
434		11	27	11:44	N	58 E 20 S	Bielid	-	1 +		B.A.A.S. 42,392,1873; Nat.7,232, 1873
435		12	12	4:53	T	87 W 39 N		Br,B	Sev.	E	Am. Jour. Sci. III, 5,318,1873
436	1873	5	15	8:05	T	53 W 48 N		Br,B	30	K	Am. Jour. Sci. III, 6,154,1873
437		6	17	8:46	T	17 E 50 N	249 - 20		45	S	B.A.A.S. 43,270,1874: H.C. 200
438		6	-	4:30	D	12 E 54 N			270	M,P	Sirius 34; 29,56,1901; K 13
439		9	20	10:57	N	3 E 46 N		Br,B	10	D	C.R. 77,678,1873
440		9	22	17:10	T	72 E 30 N	320 + 20	>- 1	45	M,S	B.A.A.S. 44,237,1875: Farrington; A.R. 12, 69, 1874; stones
441		10	13	9:41	N	16 E 48 N		X	25 +	Y	A.N. 82,289,1873:B.A.A.S. 43, 345,1874
442	1874	8	10	-	N	18 E 48 N		- 5	2.6		A.N. 84,357,1874; date ?
443		9	1	9:00	N	5 W 50 N		Br	3	Y,P	B.A.A.S. 44,206,1875
444		9	2	10:53	N	1 W 53 N		2/3 M	2	K	B.A.A.S. 46,102,1877
445		10	11	8:55	N	0 53 N		Br	6	Y,P	B.A.A.S. 44,202,1875; Met.Mag.9, 144,1874; Nat.10,482,1874
446		10	17	17:10	N	12 E 48 N		X	3	Z,K	Sirius 34,14,1901
447		12	17	10:00	N	2 E 49 N		Br	1 +	Y	Nat.11,154,1874
448	1875	2	10	6:00	T	2 E 46 N	53 + 50	Br	20	S	C.R. 80,444 + 541 + 575 + 683, 1875;H.C. 49; meteorite
449		8	10	13:24	N	2 W 55 N	Perseid	- 5	4.5	D,L	Backhouse letter
450		9	11	11:00	N	3 W 56 N		Br	3.5	S,R	B.A.A.S. 45,124,1876,Nat.12,460, 1875
451		10	24	-	-	9 E 55 N		-	45		Jahr. A. & G. 12, 1901
452		12	27	9:20	N	95 W 40 N	355 + 52	B	15	L	B.A.A.S. 44,170,1875;104 + 150, 1876; H.C. 512
453	1876	6	27	23:27	D	15 E 60 N	180 + 44	B	2	Y	Wochen.24,270,1881; Nat.16,238, 1877; meteorite
454		7	8	8:45	N	85 W 42 N	305 + 7	¼M,B	40	Y ?	Proc.Am.Phil.Soc.16,590,1877; H.C. 215, Rep.Signal Off. U.S.A. 1877, P. 287
455		7	17	8:30	T	17 E 48 N	260 + 45	- 4	12	S	Wochen.19,364,1876: K 14 d; H.C. 226
456		8	10	9:54	N	2 W 52 N	Perseid	- 3	5.5	D	B.A.A.S. 45,132,1876; Denning
457		8	11	11:24	N	0 52 N	Perseid	>-4	1	Y,S	B.A.A.S. 45,134,1876, A.R. 14, 216, 1876
458		8	12	9:04	N	8 E 52 N	Perseid	F	Many	Y	Wochen.19,341,1876
459		9	19	10:14	N	2 W 52 N	14 + 6	- 2	3	D	B.A.A.S. 46,108,1877
460		9	24	6:30	T	0 51 N	285 + 35	- 5	16	D,C,P	B.A.A.S. 46,138,1877;H.C. 363
461		10	18	14:00	N	72 W 42 N	Orionid ?	½ M	15 +	C	B.A.A.S. 46,110,1877
462		10	22	11:30	N	2 W 53 N	Sp	1/3M	8 ±	Y	B.A.A.S. 46,110,1877
463		11	17	4:24	N	162 W 64 N		M	82	D,S	Rep. Signal Off.U.S.A. 86, 1877
464		12	11	5:45	T	52 E 14 N		X	12 ±	S	Met.Mag.11,10,1876
465	1877	3	16	8:	N	26 E 34 S		<M,B	1 -	A	B.A.A.S. 46,118 + 193,1877
466		4	29	8:37	N	20 E 66 N	146 ±0	S,B	100	D,S,Y	A.N.89,279,1877;H.C. 144;K20; Wochen.23,4,1880;24,301,1881; (meteorite ??)
467		9	11	8:07	N	7 E 47 N		B	11	C	B.A.A.S. 47,280,1878
468		9	28	7:45	N	9 E 55 N		M +	75	D,S,P	B.A.A.S. 47,280,1878;Kohl; K15d
469		10	2	8:58	N	2 W 52 N	227 + 52	> -4	3	D	B.A.A.S. 47,280,1878; Denning; Nat.16,550,1877
470		10	19	6:13	T	6 W 53 N	20 + 15	Br	10	D,S,P	B.A.A.S. 47,288,1878; H.C. 400
471		11	20	P.M.	D	79 W 37 N		Br,B	Long		M.N. 38,229,1878
472		11	27	6:	T	75 E 21 N		F,B	6 +	B	Die Naturf. 12,66,1879
473	1878	1	24	7:06	N	96 W 32 N		B	?	D,L	M.W.R. 6,12,1878
474		3	24	22:22	D	3 W 56 N	328 - 15	Br	15	C	B.A.A.S. 47,18 + 32 + 291 + 302, 1878; H.C. 106
475		5	31	14:50	N	83 W 42 N		Br	3 -		M.W.R. 6,11,1878
476		7	5	15:00	N	86 W 40 N		F	1	Y	Rep. Signal Off.U.S.A. 555, 1879
477		7	29	10:20	N	3 W 55 N	306 + 28	< M	1	Y	B.A.A.S. 47,302,1878; H.C.249
478		8	7	10:53	N	8 E 52 N		- 5	Long	K	Wochen. 21,295,1878
479		8	23	10:50	N	91 W 42 N		Br	?	D,K	M.W.R.6,13,1874; Sept.1907; K 19
480		8	24	9:24	N	8 E 52 N		-	Long	Y	Wochen. 21, 297, 1878
481		9	6	9:10	N	9 E 50 N		F	5	Z,K	Wochen. 21, 312, 1878

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α δ ° °	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
482	1878	9	22	8:45	N	8 E	52 N		Br	Long	B,B	Wochen. 21, 351, 1878
483		11	22	8:	N	121 W	37 N		1/8M B	3		Rep. Signal Off. U.S.A. 616,1879
484		12	28	-	N	9 E	48 N		1	2 -		Wochen. 22, 8, 1879
485	1879	2	1	-	D	120 E	30 S		M	45		Nat. 20,121,1879
486		2	2	10:45	N ?	86 W	40 N			1		Proc.Am.Phil.Soc. 18,245,1879,
487		2	20	8:	N	87 W	36 N		Br	1 ?		Rep. Signal Off. U.S.A. 664,1879
488		3	14	15:53	N	87 W	39 N		B	Sev.	L	Proc. Am. Phil. Soc. 18,245,1879
489		9	5	7:10	T	114 W	39 N		Br	45	S	Rep. Signal Off. U.S.A. 621,1880
490		10	5	5:45	T	1 E	45 N		X	20 +	D,S	C.R. 89,871,1879
491		10	16	10:46	N	12 E	51 N	282 + 48	-2	·16	C,S	Wochen. 22,384,1879; H.C. 396
492	1880	8	6	10:	N	86 W	38 N	Perseid ??	Br	3		M.W.R. 8,15,1880
493		8	10	-	-	10 E	56 N		-	3		Jahr. A. & G. 12, 1901
494		9	5	9:30	N	71 W	42 N		Br	1.5	Y	M.W.R. 8,924,1880
495		9	21	-	-	112 W	34 N		F,B	4		Rep. Signal Off. U.S.A. 923,1881
496		12	9	5:15	T	82 W	32 N		Br	20	D,S	M.W.R. 8,16,1880
497	1881	10	17	14:20	N	88 W	31 N		B	10	Y?	M.W.R. 9,23,1881
498		11	16	6:48	N	87 W	36 N	Sp.	-6	15 *	D,S	Sid.Mes.1,174,1882; K21; Nat.25, 173,1881
499		12	8	-	-	3 W	53 N		-	?	L	Jahr. A. & G. 12, 1901
500	1882	5	11	4:	D	107 W	43 N		F	?	Y	Nat. 26,208,1882
501		7	9	7:50	T	112 W	34 N			10	D,L,S	M.W.R. 10,-, 1882; K16d
502		8	5	9:	N	87 W	36 N	Perseid ?	0	10 *	D,S	Sid. Mes. 1,175,1882; K22
503		8	8	10:00	N	72 W	41 N		B	3		Jahr. A. & G. 12.1901, M.W.R. Aug. 19, 1882
504		8	11	15:	N	87 W	36 N	Sp.	1 +	1.2 *	D,C	Sid. Mes. 1,175,1882; K23
505		8	18	10:30	N	87 W	36 N		1	10 *	D,S,Z	Sid. Mes. 1,175,1882; K24
506		8	19	13:30	N	87 W	36 N		1	3 *	D,L,E	Sid. Mes. 1,175,1882; K25
507		9	10	7:15	T	97 W	46 N		Br,B	15	Z	M.W.R. 10, IX, 27,1882
508		10	4	7:40	N	97 W	47 N		Br,B	1	D,S	M.W.R. 10, 21, 1882; K20
509		11	18	13:10	N	37 E	20 N	Leonid ?	Br	20	D	Nat. 27,149,1882-3
510	1883	1	3	7:00	N	85 W	42 N		Br	30	Y,R,S	M.W.R.11,237,1883,Jan.21,1583:K27
511		5	6	15:10	N	87 W	36 N	Eta Aq.	0	10 *	D,S	Sid. Mes. 2,148,1883; K26
512		6	8	7:51	T	58 E	36 N		>M	43	D,S,P	Obs. 6,271,1883
513		8	12	9:	N	11 E	59 N		F	1	A	Nat. 28,425,1883
514		8	12	-	-	81 W	32 N		-	10		Jahr. A. & G. 12, 1901
515		8	26	11:50	N	4 W	55 N			1	A	Nat. 28,589,1883
516		10	30	12:15	N	84 W	35 N		Br	5	Y	M.W.R. 11,237,1883
517		12	23		N	96 W	39 N		F,B	13	B	M.W.R. 11,292,1883
518	1884	5	27	8:45	T	9 E	63 N		F	5	B	Nat. 30,200,1884
519		7	3	8:30	T	77 W	43 N		¼M, B	10	S,E	Sid. Mes. 3,167,1884: Nat. 37,274,1888
520		7	12	9:30	N	87 W	36 N		1	4-*	D,S	Sid. Mes. 3,188,1884
521		7	31	14:	N	77 W	43 W		Br	Sev. *	D,C	M.W.R. 12,205,1884
522		9	5	10:05	N	2 E	49 N		Br	0.5 +	S	C.R. 99,447,1884
523		10	23	7:40	N	71 W	42 N		B	1		M.W.R. 12,263,1884
524		12	22	11:19	N	8 W	53 N		F,B	17	Y	Nat. 31,194,1885
525	1885	7	7	14:	N	77 W	43 N		Br	Sev.	S	Sid. Mes. 4,178,1885
526		11	27	6:	N	3 W	56 N		- 5	10	C	Nat. 33,176,1885
527		11	27	6:±	N	12 E	48 N		-	1.5	Y	A. N. 113,138,1885
528		11	27	6:04	N	2 W	55 N	Bielid	-4	6	D,P	Backhouse letter
529		11	27	6:20	N	14 E	50 N	Bielid	-	1.+	C	A. N. 113,230,1885
530		11	27	6:30	N	3 W	56 N	Bielid ?	Br	5	C	Nat. 33,176,1885
531		11	27	6:52	N	18 E	60 N	Bielid ?	Br	7	Y	Upsala pub.;A.N.113,141,1885
532		11	27	7:±	N	14 E	36 N	Bielid	-5	2.2	D,S	A. N. 113,226,1885
533		11	27	7:±	N	14 E	50 N	Bielid	Br	2 +		A. N. 113,376,1886
534		11	27	7:05	N	E	N	Bielid	F	7 +	D,B	C. et T. II, 1,492,1885
535		11	27	8:±	N	5 W	36 N	Bielid ?	B	25 *	D,R	Nat. 33,151,1885
536		11	27	9:	N	102 W	25 N	Bielid???	?	??	·	Am. Jour. Sci.III 33,221,1887 (doubtful train;) Iron
537		11	27	10:	N	24 E	41 S	Bielid ?	F,B	16	M,K	Ann. der Hyd. 15,80,1887; Wochen. 30,151,1887
538		11	27	-	N	6 E	51 N	Bielid ?	F	25±	Z,L	Wochen. 28,392,1885
539		11	27	-	N	60 E	25 N	Bielid	-	8 +*		M.N. 46,122,1886
540		11	27	-	N	6 E	51 N		B	15		C.et T.II 1,491,1885;C.R. 101, 1211

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						°	°	° °				
541	1885	11	27	-	N	90 E	20 N		<F	15 *		Eng. Mech. 43,103,1886
542		12	8	5:48	N	2 W	54 N		F	1		Eng. Mech. 42,318,1885
543	1886	8	10	13:34	N	3 W	51 N	Perseid	-4	3.8		Obs. 9,302,1886
544		11	2	8:05	N	3 W	51 N	55 + 9 ?	Br	3 -		Obs. 9,393,1886
545		12	4	9:17	N	2 W	52 N	162 + 58	-4	1.5		Obs. 10,66,1887; H.C. 481
546	1887	3	19	4:	D	145 E	37 S		F,B	30	Z	Obs. 10,266,1887; Nat.36,93,1887 gives March 17
547		4	21	9:08	N	34 E	47 N	214 - 13	-5,B	1	D	Wien AK. 96,2a,919,1887
548		6	12	9:	N	105 W	40 N		B	3		Republican,Denver,Colo.,June 13, 1887
549		6	17	7:45	D	2 E	48 N		-8,B	10	Z	Obs.10,300,1887;C.R.105,85,1887
550		8	18	1:	D	57 E	58 N		F	5	Y	Nat. 43,228,1891; stones
551		10	18	-	N	122 W	37 N	Orionid	Br	20 *		Sid. Mes. 7,34,1888
552		10	19	15:35	N	0	47 N		Br	7 +	M,L	C. R. 105,963,1887
553		10	23	4:24	D	15 E	46 N	224 - 8	B	99	D,S,B	Wien Ak. 97,1 + 665; H.C. 407
554	1888	6	22	12:30	N	81 W	27 N		Br	Long	C,M	M.W.R. 16,150,1888
555		7	28	8:02	T	31 E	46 N	227 + 21	Br	10	M,L	Bruun 27,249,1888
556		8	13	11:33	N	2 W	52 N	Perseid	-5	3	M	M.N.49,19,1888; Obs.11,338,1888
557		8	19	6:35	D	113 W	46 N		S,B	10		Sci. 12,132,1888; M.W.R. 16,202, 1888
558		10	20	-	N	92 W	31 N			Sev.		Times,Albany, N.Y.,1888 Oct. 26
559		11	13	16:35	N	3 W	48 N	Leonid	?,B	10	S	Cosmos 12,13,1889
560		11	13	17:19	N	2 W	52 N	Leonid	F	9	D,P	M.N.49,66,1888; Obs.11,427,1888
561		12	31	7:57	N	4 E	51 N		-5	4 +	Z,L,P	C. et T., 9,529,572,593,1889
562	1889	2	11	18:52	T	3 W	48 N		Br,B	30	D,S	Cosmos 12,338,1889
563		3	22	6:30	T	1 W	52 N		F	45	M	Nat. 39,537,1889
564		8	-	15:	N	3 W	56 N		Br	1 +	Y	Nat. 42,618,1890
565		11	23	-	-	122 W	38 N		-	Long		Jahr. A. & G. 12, 1901
566		11	23	-	-	151 W	34 S		-	60		Jahr. A. & G. 12, 1901
567	1890	1	17	5:11	T	15 E	47 N	114 + 22	<M,B	30	S	Wien Ak.99,IIa,1050,1890;H.C.24
568		5	2	5:15	D	94 W	43 N	43 + 36	Br,B	15-	M,S	(Am.Jour.Sci.39,521;40,318,1890; (H.C.147;Stones,Sci.15,304,1890
569		6	8	11:53	N	4 W	50 N		-3	5*	D,P	Backhouse letter, Denning
570		8	6	8:30	N	59 W	43 N		Br	20	C	Ann. der Hyd. 18,465,1890
571		8	23	11:30	N	21 E	52 N			20	K	Sirius 24,34,1891
572	1891	7	10	11:25	N	3 E	50 N		Br	3 +	E,B,P	C.et T.12,312,1891;BSAF 5,126,1891
573		7	29	-	-	11 E	56 N		-	12		Jahr. A. & G. 12, 1901
574		8	9	15:	N	122 W	37 N	Perseid ?	-5, B	1 + *	S	Sid. Mes. 10,470,1891
575		8	11	9:45	N	18 E	48 N	Sp. ?	-3	1		O'Gyalla 13-14,65
576		8	12	10:34	N	18 E	48 N	Perseid	1	1		O'Gyalla 13-14,67
577		8	26	6:	D	112 W	46 N		B	Sev.		Pittsburgh 'Com.Gazette' 1891 Aug. 24 (pos. 1892)
578		9	8	10:	N	23 W	51 N		Br	4	L,E	Ann. der Hyd. 19,513,1891
579		9	27	14:55	N	14 E	48 N			0.9*	D,S,P	M.V.F. 2,120,129
580		10	10	9:16	N	9 E	50 N	Sp. ?	-3	10	D,C,P	A.N. 129,43,1892;Denning; K 21
581		10	23	8:15	N	1 E	48 N		-	30	K	Sirius 34,16,1901
582		10	30	9:13	N	2 W	52 N		>1	10 *	D,S	Obs. 14,419,1891; K 22
583		11	14	5:	T	0	45 N		F,B	15	Z	Cosmos. 20,478,1891
584		11	15	-	-	74 W	41 N		-	1		Jahr. A. & G. 12, 1901
585		11	18	10:30	N	119 W	35 N		F	40+	Y	Pub. A.S.P. 4,37,1892
586	1892	5	3	16:00	N	44 W	16 N	Eta Aq.?	Br	3	C	Ann. der Hyd. 20,293,1892
587		8	17	8:30	N	N.Atlantic				90		Ann. der Hyd.; Sirius 34,16,1901
588		10	18	10:44	N	15 E	48 N	145 + 40	Br	3	Y	Bruun 39,220,1900; H.C. 339
589		11	22	8 +	N	25 E	5 S		B	1 +	M	C. et T. 14,168,1893
590	1893	3	18	6:07	T	4 W	56 N		Br	45	D,C	J.B.A.A.3,335,1893;Nat.47,495 + 516; 1893; 48,54
591		8	9	-	-	14 E	50 N			10		Sirius 34,16,1901
592		8	27	8:40	N	1 E	51 N		Br	6	S	Nat. 48,425,1893
593		10	23	-	-	N. Atlantic				35		Jahr. A. & G. 12, 1901
594	1893	11	14	14:50	N	122 W	37 N	Leonid	B	30	D,B	P.A. 1,192,1893; K28
595		11	16	15:14	N	5 E	57 N	Leonid	Br	30+	Y,L	Ann. der Hyd. 22,35,1894
596		12	8	-	-	13 E	53 N			1		Jahr. A. & G. 12,1901
597		12	30	P.M.	N	94 W	42 N		Br	5-		P.A. 1,281,1893
598	1894	2	21	7:18	N	3 W	56 N		-3	3	Y	Nat. 49, 419,1894
599		4	11	15:45	N	3 W	18 S		-	3+	K.R	Ann. der Hyd. 24,330,1896

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	° °				
600	1894	7	27	7:30	T	122 W	37 N	225 + 54	F	45	D,C	Lick Obs.Contr.5,1895; H.C. 246; Nat. 50,399,1894
601		8	9	-	-	14 E	51 N		-	1	Z	Jahr. A. & G. 12, 1901
602		8	10	13:52	N	12 E	42 N	Perseid	-4	2 *	E,L	A.N. 148,33,1898; Sirius 27,105, 1899
603		8	10	-	-	12 E	52 N		-	5		Jahr. A. & G. 12, 1901
604		8	26	10:20	N	3 W	51 N	305 + 79	X,Br	30	D,S,B,P	Mem.B.A.A. 4,17,1894;M.N.55,238, 1895,etc.; K24; Eng.Mech.60, 91, 1894
605		10	31	5:13	T	5 E	52 N		M,B	5+	S,B	C. et T. 14,457; 15,46,1893-94
606	1895	1	5	4:35	D	13 E	56 N			3	C, P	Kohl notes
607		4	19	14:47	N	3 W	51 N	Lyrid	-3	5	M,C,E	Mem.B.A.A. 5,4, +13,1897
608		10	21	12:05	N	27 E	33 S		F	30	D,E	Mem.B.A.A. 4,17,1896
609		11	14	-	-	12 E	51 N		-	41		Jahr. A. & G. 12, 1901
610		11	14	-	-	7 E	51 N		-	10		Jahr. A. & G. 12, 1901
611		11	22	6:50	N	0	51 N			3		Nat. 53,134,1895
612		12	12	17:42	N	81 W	41 N	Sp.	Br,B	5	S,B	P.A. 3,270,1898
613	1896	1	13	17:45	N	90 W	35 N		?	1	Z ? C	Nat. 53,612,1896
614		2	9	21:30	D	4 W	40 N		S+	330	D,R	Nat. 53,395,1896; C. et T.,17.49, 1896; stones
615		2	11	16:45	N	81 W	41 N		-6	10 *	D,C	P.A. 3,382,1898
616		3	4	9:14	N	0	53 N		X	16	K	Sirius 34,16,1901
617		6	13	10:59	N	0 W	52 N		-4	1-	E	Nat. 54,221,1896
618		6	19	8:57	N	145 E	35 S		> M,B	2	Y	Mem. B.A.A. 6,II, 48,1896
619		9	10	8:45	N	4 W	54 N	72 + 42	-5	0.9*		A.N.142,89,1896; H.C. 339
620		9	24	8:30	N	38 W	34 N		F	7	Y,E	Ann. der Hyd. 25,219,1897; K25
621		11	3	6:30	N	112 W	35 N		X	120	C	A.N. 177,13,1908;B.S.A.F.,22,331, 1908
622		11	13	15:40	N	6 W	53 N	Leonid	-1	0.2	D	M.N. 57,63,1896
623		11	13	16:31	N	8 E	48 N	Leonid	-3	3	D,B	A.N. 142,353,1896; K26
624		11	13	16:33	N	0	53 N	Leonid	-4	2	S	Mem. B.A.A. 6,2,51,1896
625		11	13	17:	N	118 W	34 N	Leonid	-	4+	Y	Pub. A.S.P. 9,41,1897
626		11	16	12 +	N	44 E	48 N	Leonid ??	F	Sev.	Y	Nat. 55,160,1896
627		12	16	4:30	T	1 E	51 N		Br,B	3-	D,S,P	B.S.A.F. 11,292,1897
628	1897	1	2	-	-	18 E	59 N		-	15+		Jahr. A. & G. 12,1901
629		2	24	3:45	D	110 W	32 N		B	5	Y	M.W.R. 25,56,1897; stones
630		2	-			0	50 N			3	D,S	B.S.A.F. 11,125,1897
631		5	5	6:26	D	122 W	38 N		F,B	84	Z	Pub. A.S.P. 9,146,1897
632		10	16	-	-	9 E	54 N		-	5		Jahr. A. & G. 12, 1901
633		10	27	17:35	N	79 W	41 N	Sp.	Br	1		P.A. 5,441,1897
634		10	-	5:	D	114 W	47 N		F	20	S	Pub. A.S.P. 10,84,1898
635	1898	1	2	-	-	9 E	49 N		-	3		Jahr. A. & G. 12, 1901
636		4	25	9:32	N	20 E	45 N		-4	6	D	B.S.A.F. 12,366,1898
637		7	5	8:50	N	78 W	43 N		-5,B	6	S,M	P.A. 6,365,1898; Nat. 58,604
638		7	11	7:13	T	88 E	23 N			6	D	Denning
639		8	11	10:20	N	12 E	42 N	Perseid	X	5*	D	A.N. 148,33,1898; Sirius 32,105,1899
641		9	15	8:45	N	8 E	48 N		Br	2.5		C. et T. 19,340,415 + 439
642		10	19	12: +	N	41 W	17 N	Orionid???	Br	10	D	Ann. der Hyd. 27,520,1899; K27
643		10	21	10:45	N	12 E	56 N		F	2		Pub. A.S.P. 10,84,1898
644		11	7	5:20	T	75 W	41 N	Sp.	F,B	3-	Z	P.A. 6,566,1898; B.S.A.F. 13,137,1899
645		11	12	11:20	N	71 W	42 N	Leonid	Br	1		P.A. 7,99,1899
646		11	12	14:52	N	71 W	42 N	Leonid	Br	1		P.A. 7,99,1899
647		11	12	14:57	N	71 W	42 N	Leonid	Br	1		P.A. 7,98,1899
648		11	13	12:27	N	73 W	41 N	Leonid???	Br	3		P.A. 6,85,1901
649		11	13	13:34	N	73 W	41 N	Leonid???		2		P.A. 6,85,1901
650		11	14	13:47	N	122 W	37 N	Leonid	-9,B	42	D,L	P.A. 6,555,1898; Pub.A.S.P. 10, 241,1898
651		11	14	13:50	N	88 W	44 N	Leonid	B	3	Z?,E	P.A. 7,47,1899
652		11	14	14:57	N	71 W	42 N	Leonid	> -5	2.5	S,P	P.A. 6,573,1898; Ladd Obs.notes
653		11	14	15:19	N	12 E	42 N	Leonid	1	15*	D,C,B,I	Sirius 27,106,1899
654		11	14	16:13	N	71 W	42 N	Leonid	-4	9-	D,C,B	A.J. 19,168,1899
655		11	14	17:17	N	89 W	43 N	Leonid ??	-4	3-	D	Ap.J. 9,154,1899
656		11	14	17:20	N	89 W	43 N		-3	1	M,C	Ap.J. 9,16,1899

NO.	DATE Y	M	D	HOUR	TYPE	λ φ	RADIANT α δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						° °	° °				
657		11	15			12 E 42 N			15		Jahr. A. & G. 12, 1901
658		11	16			12 E 42 N			15		Jahr. A. & G. 12, 1901
659		12	21	7:25	N	43 W 23 S		Br	1+		C.R. 128,190,1899
660	1899	8	7	13:18	N	105 W 40 N	Sp.	> M,B	Sev.		P.A. 7,448,1899
661		8	10	-	N	5 E 50 N		-2	10?	A	B.S.A.F. 14,64,1900
662		8	12	12:53	N	2 E 49 N	Perseid ?	Br	20	D,E	C.R. 129,404,1899; Obs. 22,379, 1899; K28
663		8	24	9:00	N	11 E 51 N			60	D,C,K	Sirius 32,250,1899: 33,18,1900
664		9	2	12:05	N	2 W 52 N		>-4	1		Mem.B.A.A. 9,24,1901
665		10	10	6:	T	20 E 40 N		B	8-	L	B.S.A.F. 14,18,1900
666		10	25	10:08	N	1 W 51 N	Sp.	-5	3	B	Mem.B.A.A. 9,25,1901
667		11	14	17:40	N	1 W 52 N	193 + 27	-4	5	D,S	Mem.B.A.A. 9,19 + 25,1901; H.C. 453; Nat.61,223,1900
668	1900	1	9	2:57	D	1 E 51 N	280 - 12	F	1	Y	Met.Mag.35/36,6,1900-1, M.N. 72, 426,1912
669		2	20	18:45	T	0 47 N		B	?	E	B.S.A.F. 14,149,1900
670		3	29	9:47	N	122 W 37 N		Br	95	D,K	Publ.A.S.P. 12,128,1900
671		4	10	18:45	D	73 W 19 N		Br	45	C	B.S.A.F. 14,383,1900
672		4	16	7:05	T	123 W 42 N		F	30	B,Y	Pub.A.S.P. 12,132,1900
673		7	15			16 E 51 N			1		Jahr, der Sch, Gesell. Breslau II 37,1900
674		7	16	8:20	N	98 W 20 N		1/4 M	1		B.S.A.F. 14,472,1900
675		7	17	8:47	T	5 E 54 N	249 - 20	Br	47	D	Mem.B.A.A. 10,1, 19, 1902; H.C. 227; etc.
676		9	2	6:45	D	2 W 55 N	334 + 57	Br	46		Mem.B.A.A. 10, 1, 19, 1902; H.C. 326; Obs. 23,387,1900
677		10	27	11:18	N	6 W 52 N	136 + 34	-5	13*	D,P	Nat. 63,14,1900; H.C. 415; etc: K29
678		12	7	3:20	D	105 W 39 N	50 + 18	-5,B	60+		P.A. 9,426,1901
679		12	16	4:42	T	9 E 56 N		M,B	15+	S,P	Sirius 34,53,1901:
680		12	18	12:45	N	2 W 54 N	162 - 5	Br	15	D,C	Mem.B.A.A. 11,17,1901; Denning
681		12	25	13:05	N	152 E 33 S		Br	30	D,R	J.B.A.A. 12,28,1901
682	1901	1	10	9:03	N	5 E 51 N		-2	10		B.S.A.F. 15,110,1901
683		4	29	15:15	N	32 E 48 N	211 + 4	1/4 M	4-		Bruun 41,160,1902
684		7	5	8:45	T	0 45 N		Br,B	4?	B	B.S.A.F. 15,419,1901
685		7	7	10:45	T	6 W 58 N		Br	5	C	Mem.B.A.A. 11,28,1903
686		8	11	11:02	N	1 E 51 N		-4	1		Nat. 64,411,1901
687		10	19	11:30	N	4 W 51 N	Orionid	-4	5	D,B,E	Mem.B.A.A. 11,21,1903: K30
688		10	19	12:03	N	14 E 48 N	Orionid	Br	6*	D,B	Mitt.V.A.P. 11,109,1899
689		10	19	16:03	N	14 E 48 N		-3	10*	D,C	Mitt.V.A.P. 11,109,1899
690		11	13	6:53	N	3 W 55 N	87 + 34	M	1.5	D,C	Mem.B.A.A. 11,17,1903; H.C. 450; etc.
691		11	14	14:	N	110 W 50 N	Leonid	Br	4		P.A. 10,16,1902
692		11	14	14:54	N	88 W 40 N	Leonid	Br	16	D,C	P.A. 10,51+,107,1902: Barnard notes; K30
693		11	14	15:05	N	88 W 42 N		X	50±	D,C,P	Barnard letters
694		11	14	15:10	N	93 W 44 N	Leonid	Br	3	Z ?	P.A. 9,561,1901
695		11	14	15:15	N	118 W 34 N	Leonid	F	14	D,C	P.A. 10,16,1902; M.W.R. Sept 1907; E.M. 74,381,1901; K31
696		11	14	16:10	N	110 W 50 N	Leonid	Br	20	D,B	P.A. 10,51,1902; M.W.R. Sept. 1907; K32
697		11	14	16:15	N	93 W 44 N	Leonid	Br	6		P.A. 9,561,1901
698		11	14	16:50	N	118 W 34 N	Leonid ?	F	6	R	P.A. 10,18,1902
699		11	14	17:09	N	71 W 42 N	Leonid	-3	20*	Z?,P,E	P.A. 10,49,1902; Denning: K29
700		11	14	17:18	N	93 W 44 N	Leonid	Br	9+	D	P.A. 9,561,1901
701		11	14	17:40	N	78 W 38 N	Leonid	< -2	3+	S	Olivier note
702		12	4	5:36	N	0 52 N	263 + 36	> M	5	Z??	M.N. 62,170,1901; J.B.A.A. 12,127,1902
703	1902	1	24	12:13	N	3 W 54 N		Br	10	Y	Eng. Mech.75,32,1902
704		2	9	7:40	N	0 50 N		-4	1.5		B.S.A.F. 16,197,1902
705		7	13	10:50	N	0 51 N	315 + 31	> M	2+	S,Y	Nat. 66,309,1902; Obs. 25,293,1902
706		8	27	15:13	N	0 51 N		-5	1.5	S	Mem.B.A.A. 12,1,29,1902
707		9	10	12:45	N	17 W 31 N		Br	Sev.	D	Ann.der Hyd. 30,552,1902; K32
708		9	15	17:45	T	84 W 42 N		½M	20 ±	S,Y	M.W.R. 32,172,231,1904
709	1903	5	18	9:30	N	12 E 48 N		F	30	S,R,P	Pub.A.S.P. 16,27,1903
710		6	28	11:28	N	9 E 49 N		-3	25	D,B	A.N. 163,251,1903; K33

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	° °				
711	1903	6	30	8:52	T	2 E	47 N		> M	5	D,B	B.S.A.F. 17,381,1903; Obs.26,331, 1903; Mem.B.A.A. 13,14,1906
712		8	21	13:20	N	0	52 N		M	1		Mem.B.A.A. 13,21,1904-6
713		10	16	10:00	N	4 W	40 N		Br,X	120	D,R,P	B.S.A.F. 18,136,1904; Sirius 37, 6,1904; K34
714		11	1	16:44	N	12 E	49 N	49 - 5	Br	8	Y	Wien Ak. 114,505,1905; H.C. 421
715		11	15	14:00	N	0	52 N	Leonid	-5,B	8*	D	Mem.B.A.A. 13,21,1906; Nat.69, 65,1903
716		11	15	15:40	N	0	52 N	Leonid	-3	20	D,S,L	Obs. 26,468,1903
717		11	28	10:15	N	158 W	20 N		Br	2 +		A.N. 166,381,1904
718	1904	5	18	9:30	N	10 E	56 N		F	30	S	Pub.A.S.P. 17,19,1905
719		8	11	-	N	72 W	44 N	Perseid	Br	4		Nat. 70,536,1904
720		10	12	11:39	N	0	52 N	Sp.	X	30*	S	M.N. 65,89,1904
721		11	14	14:43	N	3 W	51 N	Leonid	-3	3	D,C	Mem.B.A.A. 14,18,1906
722		11	14	14:56	N	88 W	40 N	Leonid	-7	15*	D,R,P	P.A. 13,56,1904; M.W.R. 36,410, 1908
723		11	14	16:24	N	2 W	54 N	Leonid	0	1		Mem.B.A.A. 14,8,1906
724		11	14	17:00	N	10 W	42 N	Leonid	F,B	25	D,S,P	Ann.der Hyd.33,380 + 476,1905 (2 ships); K35
725		11	16	16:25	N	0	52 N	Leonid	-3,B	1.9		Obs. 28,54,1905; M.N. 65,154,1904
726		12	13	14:45	N	11 E	55 N		F	Sev.	A??	Pub.A.S.P. 17,19,1905
727		12	27	11:14	N	19 E	47 N		F,B	2		Sirius 38,89,1905
728	1905	3	20	0:15	D	11 E	60 N		F,B	15 +	D,S	Kohl Table; Sirius 38,152,1905; K17d
729		6	11	8:43	T	17 E	46 N	218 - 4	$\frac{1}{2}$M	60 -	D,C	Bruun 45,161,1906; H.C. 196; etc.
730		7	9	12:27	N	12 E	56 N		F?	4	S	Pub.A.S.P. 18,126,1906
731		8	3	8:56	N	10 E	48 N	317 - 11	M	Long	D	A.N. 170,1,1905; Sirius 38,251, 1905; H.C. 264
732		10	12	11:39	N	0	52 N		X	21*	B,B	J.B.A.A. 15,177,1905; M.N. 65,89, 1904
733		10	13	5:30	T	77 W	41 N		Br	10	M,S,P	Sci. 24,150, 1906, reports
734		11	13	7:30	N	8 E	48 N		-	10	S	Sirius 39,19,1906
735		11	29	P.M.	D	18 E	34 S		X,B	120±	M,R	Eng.Mechanic 82,493,1906; B.S.A.F. 20,243,1906
736		12	12	5:	T	108 E	41 N		F,B	30	D,S,P	Cosmos 54,366,1906
737		12	30	4:26	T	3 W	55 N	40 + 23	- 8	15*	D,R,P	Jour. B.A.A. 16,162 + 191; Obs. 29, 134,1906; K18d
738	1906	1	1	5:+	N	25 E	43 N		M	2 -		B.S.A.F. 21,123,1907
739		1	27	8:33	N	2 E	53 N	214 + 53	M	10 +	Y ?	J.B.A.A. 16,253,1906; Nat. 73,427, 1906; M.N. 72,426,1912
740		1	28	8:40	N	16 E	48 N		M?	5		Wien Meteor. Zeits. 23,87
741		6	21	12:30	N	20 W	27 N		Br	15		Ann. der Hyd. 35, 235, 1907
742		7	11	10:55	N	12 E	52 N	350 + 8	$\frac{1}{2}$M	5		Wien Ak. 118,185,1909; H.C. 217
743		8	1	7:44	T	15 E	48 N	264 + 22	M-	30	D,S	Bruun, 52,1913; H.C. 258; K19d
744		8	11	12:47	N	78 W	38 N	Perseid	-3	0.3	D,P	Olivier notes
745		11	16	13:20	N	0	52 N	Leonid	1/4 M	3	D	M.N. 67,276,1906, Obs. 34,408,1911
746		12	18	6:08	N	10 E	46 N		F	2	S,P	Kohl Table; A.N. 173,367,1907
747	1907	2	10	5:40	T	74 W	43 N		B	15	D,S,P	M.W.R. 35,447,1907; Denning
748		4	20	6:	D	40 E	50 N		M	(2+)	A	B.S.A.F. 21,309,1907
749		7	11	9:55	N	38 E	45 N		M	1	Y	B.S.A.F. 21,412,1907
750		9	10	8:34	N	15 E	48 N	320 + 29	Br	5	Z	Bruun 47,32,1908; H.C.344; K36
751		10	5	9:55	N	78 W	42 N	57 - 16	$\frac{1}{2}$M	5	C,E	M.W.R. 36,142,1908
752	1908	4	12	6:	D	61 W	32 S		B,M	60	Y	M.V.F.A. 18,52,1908; Nat. Rund. 23,336
753		7	31	11:12	N	2 E	48 N	Perseid	Br	20*	D,C,P	B.S.A.F. 22,458,1908; K37; Nat. 78,612,1908, Cosmos 59,447,1908
754		8	3	9:05	N	34 E	50 N	Perseid		2	S	Jahr. der Sch. Gesell. Breslau II 293,1913
755		10	22	12:55	N	9 E	49 N	33 + 16	-5	30*	D,S	A.N. 179,237,1908; J.B.A.A. 19, 152,1908; H.C. 409; K38
756		11	26	0:35	D	176 E	39 S		Br,B	5	M,L	Obs. 32,173,1909; Nat. 80,128, 1909, Stone
757		11	28	15:51	N	12 E	51 N		Br	29	D,S,R	A.N. 180,14; 181, 94, 1909
758		12	12	7:23	N	16 E	48 N			1		M.V.F.A. 4,1909; G.A. 2,16,1909
759	1909	1	2	10:05	N	32 E	30 N	Quadrantid?	Br,B	1.6 *	S,P	J.B.A.A. 19,177,1909

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α	δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						°	°	°	°				
760		2	22	7:30	N	2 W	50 N	196	+ 20	½ M	120-	D,C,P	(Obs.32,132,+172,1909;C.et T. 30, (120; H.C. 72; K39, Ann. der Hyd.37, (519,1909; Eng.Mech. 89,112,1909
761		3	14	7:45	T	18 E	34 S			Br	10	Z,S	Nat. 80,248,1909
762		4	20	9:59	N	0	50 N	Lyrid		-5	3	D,R,P	B.S.A.F. 23,351,1909; Nature 81,298, etc.
763		5	8	13:30	N	152 E	34 S	246	+ 22	M,B	Sev.		J.B.A.A. 20,33,1909
764		6	15	16:10	N	105 E	22 N			Br	9		B.S.A.F. 23,519,1909
765		7	9	7:55	T	43 W	44 N			Br,B	10	D	Ann. der Hyd. 37,520,1909
766		8	11	12:03	N	12 E	45 N			-	1	C	Mem. Spetti. Ital. 38,172,1909
767		8	12	9:42	N	0	51 N	Perseid		-5	2.5	D,S	B.S.A.F. 23,519,1909; Obs. 32,349,1909
768		9	1	8:53	N	1 E	37 N			> M	3 *	Z	B.S.A.F. 23,520,1909
769		10	22	16:55	N	2 E	49 N			Br,B	5		B.S.A.F. 24,21,1910
770		11	28	P.M.	T	91 W	42 N			F,B	?	Y	P.A. 39,295,1931
771		12	7	22:30	D	123 W	38 N			Br	Long		M.W.R. 39,1909,1911
772		12	8	14:	N	2 E	49 N			Br	Long	C	B.S.A.F. 24,175,1910
773	1910	2	17	6:08	T	0	53 N	72	+ 43	- 5	30	D	Obs. 33,134,1910; J.B.A.A.20,332, 1910; H.C. 61
774		4	8	7	T	32 E	55 N			Br	?	D,P	Kareev Report
775		6	18	12:30	N	2 W	46 N			Br,B	20	D,B,K	B.S.A.F. 24,479,1910
776		8	19	7:10	T	95 W	31 N			Br,B	20	E ?	M.W.R. 38,1240,1910
777		8	28	11:29	N	4 W	53 N			Br	4-	D	Obs.33,407.1910; J.B.A.A. 21,65,1911
778		9	23	6:31	T	15 E	48 N	224	- 10	< M	15	S	Wien.Ak.121,1883,G.A.No.64;H.C.359
779		9	25	7:40	N	1 E	49 N			B	1+		B.S,A.F. 24,481,1910
780		10	3	8:50	N	27 E	28 S			½ M	3	D,A	Nat. 84,439,1910
781		10	4	10:45	N	12 E	57 N				2.5	M,B	Kohl Table
782		10	16	21:05	D	89 W	32 N			F,B	45-	Y	M.W.R. 39,16,1911; Stones
783		10	28	9:45	N	33 E	15 N			F	8	S	B.S.A.F. 25,139,1911
784		10	30	11:28	N ?	13 E	56 N			S	6		G.A.d'Anvers. 1,8,1911
785		11	16	12:26	N	5 W	55 N	Leonid		½ M	20	D	Nat. 85,150,1910; Obs. 34,408, 1911,Eng.Mech. 92,468,1910
786		11	24	17:50	T	75 E	23 N			Br	20	S,P	B.S.A.F. 27,28,1913
787	1911	4	15	5:50	D	41 W	22 S			B	20	S	B.S.A.F. 25,278,1911
788		6	8	11:±	N	99 W	43 N			< Br	16+	D,R,S	P.A. 19,454,1911
789a		7	27	11:45	N ?	5 E	51 N			F	3 -	K	G.A.d'Anvers. 1,40,1911
789b		7	27	12:	N	9 E	48 N			F,B	1+	C	B.S.A.F., 25,483,1911 same meteor as 789a ?
790		9	16	8:15	N	89 W	43 N			Br	5	D,R	P.A. 19,590,1911
791		10	3	8:30	N	28 E	26 S				4	D	Denning
792		12	7	22:30	D	123 W	38 N			F,B	Long	Y	M.W.R. 39,1909, 1911
793	1912	4	7	7:08	T	15 E	50 N	45	+ 62	Br	5+	S	Bruun 52,-,1914; H.C.120
794		4	7	8:42	N	45 W	13 S			-3	5.7?	A,S	B.S.A.F. 26,519,1912
795		6	2	5:07	D	22 E	30 S	?	- 30	Br	60	D,S,E,P	Eng.Mech.90,540,1912; B.S.A.F.29, 81,1915; Union Obs.Cir. 1, Denning: B.A.A.23,178,1913
796		6	3	8:55	N	86 W	40 N			Br	5		The News, Indianapolis, June 4, 1912
797		7	19	6:30	D	110 W	35 N			F,B	?	Y,E	Am.Jour.Sci. IV, 34,437,1912;stone
798		8	6	0:10	D	29 E	32 S			½ S,B	5	R	Union Obs. Cir. 1,4
799		10	23	7:	N	3 E	50 N			B	2-	B,B	B.S.A.F.26,519,536,1912; Cos.67, 481
800	1913	1	10	12:26	N	24 E	52 N			F,B	30+	C,S	A.N.236,64,1929
801		2	27	16:40	N	4 W	50 N			Br	2.3		B.A.A.23,274,1913
802		6	14	8:04	D	1 E	52 N	263	+ 64	> M	3-	Y	B.A.A.24,23,1913
803		6	14	10:02	T	3 W	50 N	282	- 23	B	1.5	D	B.A.A.24,24,1913
804		7	21	8:05	T	92 W	42 N			-4	10	S	M.R., S.P.A. 5,48,1913
805		9	1	10:16	N	0	53 N			Br	1	S	B.A.A.24,198,1913
806		10	7	10:35	N	4 W	52 N			L	0.5	Y	Nat.92,206,1913
807		10	27	9:12	N	11 E	50 N			-3	8*	D,R,P	A.N.197,97,1914; K40
808		10	29	11:25	N	10 E	54 N			Br	8*	D,S,P	H.und E.26,334,1914; K42
809	1914	1	12	5:45	N	107 W	45 N			X	22	D,S,P	H.A. Frise letter; M.W.R.42,38, 1914
810		6	14	8:04	D	1 E	52 N	263	+ 64	F,B	3		J.B.A.A.23,440,1913
811		6	24	15:10	N	35 W	85 N			Br	30		M.R.,S.P.A.,6,41,1914

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
812	1914	8	14	9:34	N	0	53 N	Perseid	> -4	2		Obs.37,364,1914; M.N.75,450,1915
813		10	24	16:06	N	119 W	34 N	Sp	X	5	D,P,C	F.H.Hays letter
814		12	24	15:15	N	11 E	59 N		F,B	15 ±	D,R	Sirius 48,92,1915; K41
815	1915	7	8	12:45	N	24 E	51 N		X	5	D,R	Sirius 48,267,1915
816		8	12	13:34	N	87 W	37 N	Perseid	-2	1.5		R.C.Lamb report
817		8	13	11:08	N	1 W	52 N	Perseid	-4	0.5		J.B.A.A.26,183,1915; H.C.568
818		10	5	10:56	N	5 W	50 N	248 + 72	> ½M	18	D,R,P	J.B.A.A.26,23,1915; H.C.583: B.S.A.F. 30,70,1916
819		10	28	9:00	N	74 W	41 N		-3	1		R. Lambert report
820	1916	1	3	4:35	D	83 E	57 N		F	20+	S,P	Photo by Volkor, mss.
821		4	3	3:25	D	9 E	51 N	357 + 80	Br,B	15	D,S,P	Sirius 51,177,1918: H.C.531:K20d; iron
822		4	3	13:28	N	26 E	53 N		Br	22	D,S	Sirius 49,121,1916
823		6	28	15:30	T	4 E	44 N		< M,B	30		B.S.A.F. 30,430,1916
824		7	26	10:07	N	0	52 N	35 + 51	-4	3*	Z	J.B.A.A.27,39+110,1916; H.C. 564
825a		8	7	9:40	N	3 E	46 N	(Perseid)	B	4	D,S	C.R.163,239,1916) Probably
825b		8	7	9:48	N	1 E	46 N			4*	D,P	B.S.A.F.30,430,1916) same meteor
826		9	25	10:30	N	2 E	50 N		Br	15		B.S.A.F.30,430,1916
827		10	17	23:47	D	132 E	45 N			35	L	Sirius 52,52,1919; iron
828	1917	5	31	9:55	N	95 W	43 N		F,B	1+	Y	P.A.25,483,1917
829		6	29	9:01	N	15 E	51 N	249 - 20	F,B	18	S,B	Sirius 50,210,1917: H.C.552
830		7	18	4:00	D	123 W	38 N		F	17	D,S	Pub.A.S.P.29,191,1917
831		10	1	10:30	N	99 W	31 N		F,B	45	R,C	Univ.of Texas, Bul.1772,1917
832		10	17	14:10	N	0	52 N	Orionid	-6	15	D	J.B.A.A.28,118,1918; H.C.589
833		10	19	12:17	N	0	53 N	Orionid		6		Denning letter
834	1918	2	25	9:	N	140 W	67 N		S,B	5	L	N.Y.Times 1918-7-8± Jour.R.A.S.C. 12,180,1918
835		4	23	7:20	T	81 W	34 N		F,B	40	D	M.W.R.46,357,1918: P.A.27,126,1919
836		5	25	21:40	D	31 E	26 S		B	30		Union Obs. Cir.44,383,1919,stones?
837		Summer		-	-	82 W	33 N		F	1.3 *	C,B,B	P.A.26,585,1918
838	1919	4	23	11:12	N	5 E	46 N	Sporadic	M	3 *	Z,C,L	B.S.A.F.33,259,1919
839		6	13	7:15	D	76 W	39 N		F,B	60?	D	P.A.27,477,1919
840		10	27	15:18	N	3 W	51 N	99 - 16	-5,B	2	Y	Obs.42,415,1919
841		12	24	15:25	N	8 E	62 N		F,B	15	C	Himmels. 46,161,1926
842	1920	1	16	4:55	T	0	53 N	132 + 33	Br	15		Obs.43,96,1920: Nat.104,544,1919
843		5	2	15:30	N	10 E	35 N	Eta Aq.	Br	8	S,E	B.S.A.F. 43,269,1920
844		6	8	8:45	N	96 W	36 N		F,B	18	D	Reports to A.M.S.
845		6	30	20:39	D	7 E	50 N	139 - 2	F,B	2	Y	Sonneberg Mitt. Nr. 4; H.C.554, stones
846		7	17	8:06	T	12 E	50 N	144 + 60	F,B	3		Sonneberg Mitt. Nr. 4; H.C.559
847		8	11	-	N	68 E	42 N		-	?	D,S,P	Mss.
848		9	7	9:35	N	5 E	45 N		> -4	4	S,E	B.S.A.F.34,528,1920
849		11	7	14:49	N	78 W	38 N		X	10.5	D,P,K	Olivier notes
850	1921	4	19	21:00	D	84 W	32 N		F	2	S	Am.Jour.Sci.V,3,211,1922; P.A.29, 307,1921: Iron
851		4	27	12:42	N	4 E	51 N		X	40	D,E	B.S.A.F.36,171,1922; G.A.d'Anvers 8,29,1921; etc.
852	1922	9	22	6:35	T	16 E	44 N		M	2	Y,K	Sirius 56,116,1923
853		11	14	13:11	N	9 E	49 N		X	65	D,C,R	A.N.218,47,1923
854		11	14	15:16	N	94 W	42 N	Leonid	-2	2.9		P. Mead report
855		11	14	15:26	N	94 W	42 N	Leonid	-2	1.5		P. Mead report
856		12	28	5±	T	74 E	32 N	Quadr.	Br	20-	D,S	Obs.46,94,1923; H.C.611;M.B.A.A. 24,80,1923
857	1923	8	11		N	71 W	43 N	Perseid	1/3 M	0.7	D	P.A.32,195,1924
858		9	7	7:45	N	0	53 N	260 + 4 ?	Br	12	D,R	Obs.46,318,1923; Nat.112,454,+520, 1924
859a		9	11	15:30	N	38 W	40 N	347 + 2 ?	-3,B	20 +	Y	Obs.46,346,1923;U.S.N. Hy.O) Same
859b		9	15	15:18	N	38 W	46 N			20		Jour.R.A.S.C.17,356,1923) meteor!
860		10	30	17:50	N	148 E	33 N		B	6	S,P	H.G.Finne letter
861	1924	1	11	6:00	N	79 W	16 N		Br	7		U.S.N. Hy. O.
862		4	3	15:16	N	66 W	40 N		Br	6	Y,R	U.S.N. Hy. O.
863		5	18	12:	N	9 E	50 N			2.5		A.N.222,287,1924
864		5	21	5:40	T	26 E	26 S		B	30	D,S,P	Union Obs.Cir.66,328,1925
865		5	22	7:47	T	76 W	39 N		-	5	D,B,B	P.A.32,447,1924
866		6	14	12:	N	9 E	50 N		-	2.5		A.N.222,287,1914
867		6	-	6:30	D	101 W	48 N		Br	60	Z	A.Halverson report

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α	δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	°	°				
868	1924	10	30	10:35	N	57 E	10 N			Br	23	S,Y	Marine Obs.2,158,1925
869		11	1	15:53	N	24 W	49 N			Br	Some *	S,M	Marine Obs.2,175,1925
870	1925	1	5	5:27	N	8 W	45 N			B	7		Marine Obs.2,7,1925
871		3	19	10:56	N	46 E	42 N			Br	1.5 *	D,P	Astapowitsch letter
872		5	3	15:24	N	130 W	35 N			-	25 *	Y	U.S.N. Hy. O.
873		6	4	4:05	D	0	53 N	217	+ 14	B	7-		Obs.48,229,1925
874		7	9	10:27	N	60 W	50 N			Br	10	D,R,P	Marine Obs.3,109,1926
875		8	20	8:42	N	32 E	49 N	73	+ 64	-8,B	18 *	D,L,P	Mirov.A.B.24,2,1929; Mss.
876		9	5	14:20	N	114 W	26 N			B	4		U.S.N. Hy. O.
877		10	15	16:30	N	57 W	25 N			Br	3		U.S.N. Hy. O.
878		10	16	8:08	N	1 E	46 N			X	33 *	D,R,P	B.S.A.F.40,38,1926
879		12	29	5:16	T	77 W	43 N			< M	20	D,C	P.A.34,1,1926 (one of 7(?) trains: see note)
880	1926	2	12	14:20	N	71 W	31 N			-	5	D,S	R.C.Spaulding letter
881		5	15	7:15	T	153 W	23 N			B	25	S,Y,P	U.S.N. Hy. O.
882		6	1	15:35	N	90 W	30 N			Br	15		N.O. "Picayune" 1926 June 3
883		6	20	15:19	N	50 W	23 N				15		Obs. 49,287,1926
884		8	8	19:42	N ?	24 E	38 N			B	Sev.	L	B.S.A.F. 41,437,1927
885		9	5	9:02	N	34 E	50 N			F	20 *	D,P	Mss.
886		9	15	10:59	N	0	53 N	140	+ 37	M	20		Obs.49,314,1926; Nat.118,495,1926
887		9	17	-	N	97 W	33 N			B	1	D ?	J.H.Logan report
888		10	9	10:16	N	0	53 N	262	+ 55	- 5	30 +	D,C	Obs. 50,120,1927; 49,344,1926
889		10	23	18:20	T ?	-	-			Br	1	S	Marine Obs. 4,191,1927
890		11	14	14:	N	74 W	19 N	Leonid ??		Br	10	K,E	U.S.N. Hy. O.
891		11	28	18:	N	74 W	40 N			B	5+		C.S.Maddock report
892	1927	3	29	10:10	N	48 E	52 N				60	D,P	Mss.; 5 Russian reports
893		7	11	12:40	N	86 W	20 N			B	4	Y	U.S.N. Hy. O.
894		7	25	7:36	T	118 W	37 N			Br	10	S	Pub.A.S.P. 39,332,1927
895		7	30	9:48	N	3 E	47 N	302	- 12	-9	1	B,B	B.S.A.F. 42,135,1928
896		9	4	14:13	N	39 W	36 N			-	3.5	S,L	Hy. O. U.S.N.
897		9	25	8:15	N	74 W	41 N			B	3 +	D,L	F.C.H. Unger report
898		10	1	11:35	N	0	52 N	91	+ 15	Br	3 -		Obs. 51,49,1928
899		10	16	11:55	N	65 W	18 N	Orionid			10	C,K	Mss. from U.S.W.B.
900		10	16	14:47	N	42 E	2 S	Orionid		Br	1.2 *	D	Marine Obs. 6,205,1929
901		10	21	7:	N	67 W	15 N	Sp.		Br	60		U.S.N. Hy. O.
902		11	1	12:25	N	21 W	52 N				7	Z ?	Marine Obs. 6,222,1929
903		11	1	13:30	N	118 W	33 N			B	8 *	Z,S,E	U.S.N. Hy. O.
904		11	2	14:22	N	76 W	19 N			Br	20	Z ?	U.S.N. Hy. O.
905		11	15	15:25	N	110 W	20 N			< Br	8 *		U.S.N. Hy. O.
906		11	27	15:20	N	120 W	5 N			Br	1-	S	Marine Obs. 6,226,1929
907		12	2	4:30	T	101 W	46 N			B	5	E	A. Finch report
908		12	14	6:38	N	74 W	41 N	Geminid		-2	3	Y	P.A. 36,135,1928
909	1928	1	2	9:30	N	1 W	17 S	Sp.		-4,8	5-	Y	U.S.N. Hy. O.
910		1	18	14:20	N	168 E	24 S			Br	1.2		U.S.N. Hy. O.
911		2	15	11:33	N	42 W	23 S			Br	3.3		Marine Obs. 6,35,1929
912		4	5	14:	N	74 W	19 N			B	1		U.S.N. Hy. O.
913		4	20	16:	N	74 W	27 N			Br	2		U.S.N. Hy. O.
914		4	21	10:40	N	20 W	18 N	Sp.		B	15		Marine Obs. 6,79,1929
915		4	21	15:54	N	78 W	26 N	Lyrid			6	D,S,P	Marine Obs. 6,79,1929
916		5	7		T	74 W	53 N				120		Letter from F. Watson
917		6	23	4:10	D	98 W	32 N			S,B	60 +	L,E,P	Univ. of Texas Bul.2901,1929
918		7	16	14:35	N	151 W	23 N			B	2.5*		Mss. U.S.W.B.
919		7	26	18:23	D	28 E	25 S	234	- 52	Br	20	C	Obs.51,352,1928; 52,121,1929
920		8	8	8:56	N	98 W	32 N	288	+ 64	Br	2	D,R,E	P.A. 37,275,1929
921		10	1	7:10	N	120 E	10 N			M,B	15		Pub. Manila Obs. 1,9,18
922		10	14	13:27	N	65 W	34 N			Br	10		M.S.S. U.S.W.B.
923		10	15	13:09	N	48 W	40 N	Orionid ?		B	1.4	Y	U.S.N. Hy. O.
924		10	16	14:06	N	43 E	14 N	Orionid??		B	14 +	D,C,S,P	Marine Obs. 6,220,1929
925		10	16	15:18	N	176 E	42 S			- 2	1.4	D	Trans.N.Z.Inst. 60,464,1929
926		10	20	16:19	N	73 W	41 N			B	20	Y	U.S.N. Hy. O.
927		10	21	15:27	N	68 W	43 N	Orionid		B	?	D,S,P	Marine Obs., 6,220,1929
928		11	11	14:14	N	39 W	34 N	Sp.		30			U.S.N. Hy. O.
929		11	12	14:47	N	17 W	54 N	Leonid ?		F,B	6		Mss. U.S.W.B.
930		11	13	13:47	N	92 W	23 N	Leonid ?		F,B	10		U.S.N. Hy. O.
931		11	14	14:50	N	88 W	10 N	Leonid ?		Br	8	B	Mss. U.S.W.B.
932		11	14	15:52	N	63 W	75 N	Leonid ??		B,-4	1.2		U.S.N. Hy. O.

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
933	1928	11	14	16:	N	89 W	43 N	Leonid	¼ M	12	Y	J. Stebbins report
934		11	15	12:22	N	74 W	35 N	Leonid ??	Br	5+ *	S	U.S.N. Hy. O.
935		11	15	12:28	N	73 W	38 N	Sp.	Br	5		U.S.N. Hy. O.
936		11	15	13:18	N	75 W	36 N	Leonid	Br	4 *	C,E	U.S.N. Hy. O.
937		11	15	14:35	N	59 W	8 N			15	D	Mss. U.S.W.B.
938		11	15	15:16	N	108 W	21 N		Br	15	S	Mss. U.S.W.B.
939		11	15	15:18	N	99 W	19 N	Leonid	Br	10		Tacubaya Mss.
940		11	15	15:38	N	36 W	13 S	Leonid	B	30	D,L,L	Mss. U.S.W.B.
941		11	15	15:55	N	37 W	11 S	Leonid ?		25	E,L	Marine Obs. 6,241,1929
942		11	15	17:18	N	70 W	27 N	Leonid	Br	1-	Y	U.S.N. Hy. O.
943		11	15	17:40	N	15 E	43 N	Leonid	Br	2.8		U.S.N. Hy. O.
944		11	16	13:35	N	174 E	31 N	Leonid ?		20	L	MSS. U.S.W.B.
945		11	16	16:07	N	98 W	32 N	Sp.	> M,B	8	Y	O.E. Monnig reports
946		11	16	16:48	N	0	53 N	Leonid	Br	5		Obs. 52,123,1929
947		11	16	17:20	N	5 E	37 N	Leonid ??	B	12		U.S.N. Hy. O.
948		11	19	15:00	N	9 W	52 N		B	?	Y,C	U.S.N. Hy. O.
949		11	20	13:34	N	94 W	14 N	Leonid ?		1		Mss. U.S.W.B.
950		12	9	15:54	N	120 W	34 N	Sp.		5	Y	U.S.N. Hy. O.
951	1929	1	16	13:18	N	74 W	26 N		Br	2	Y	U.S.N. Hy. O.
952		1	19	15:32	N	94 W	14 N		Br	5	Y	U.S.N. Hy. O.
953		2	1	10:51	N	38 E	47 N		Br	3-		Mirov. A.B. 25,4,1929
954		4	8	12:20	N	155 W	3 S		- 5	17	C,P	Marine Obs. 7,84,1930
955		5	31	13:58	N	119 E	32 N		Br	1		U.S.N. Hy. O.
956		7	2	9:56	N	130 W	24 S		B	26	D	Mss. U.S.W.B.
957		7	25	9:30	T	12 E	53 N		Br	10	D	Das Weltall 28,175,1929
958		8	5	13:43	N	57 W	36 N	Perseid??	Br	3		Marine Obs. 7,175,1920
959		8	7	12:33	N	30 W	10 N		?	2 *	D,C	U.S.N. Hy. O.
960		8	11	13:00	N	105 W	39 N		Br	5	D,C,P	A.B.Sperry letter
961		8	19	0:45	D	75 W	45 N		Br	30		J.L.Bedford letter; Jour.R.A.S.C. 23,378,1929
962		9	11	15:28	N	136 E±	36 N			1		The Heavens (Jap.) 10,121,1930
963		11	1	16:20	N	120 W	34 N		?	30		O.G.Martin letter
964		11	16	15:30	N	100 W	17 N		Br	5		U.S.N. Hy. O
965		12	28	11:20	N	37 E	23 N		-4	1.5 *		Marine Obs. 7,243,1930
966	1930	2	16	16:08	N	92 W	35 N		B	5		P.A. 38,387,1930′; stones
967		5	21	10:31	N	97 W	32 N		-1	2 *	D,Y,K	P.A. 38,442,1930
968		6	3	8:30	T	97 W	45 N		Br,B	30 +	L	E. Gruse letter
969		6	12	8:	T	89 W	37 N		Br	10	D,C,P	Miss M.L.Jones letter
970		6	30	15:15	N	167 E	26 S		M	3	D	U.S.N. Hy. O.
971		7	4	10:05	N	97 W	47 N		½ M	1.3	Y	P.A. 38,510,1930
972		7	5	-	N	5 W	36 N		Br	5	Y	U.S.N. Hy. O.
973		7	5	14:36	N	14 W	33 N		Br	1	D	U.S.N. Hy. O.
974		7	26	9:51	N	55 W	27 N	Delta Aquarid	-5	7		U.S.N. Hy. O.
975		7	28	12:58	N	87 W	26 N	Sp.	Br	1		U.S.N. Hy. O.
976		8	2	12:15	N	76 W	41 N		Br	1		Mrs. E. Grouser letter
977		9	1	15:52	N	54 W	33 N		B	7	R	U.S.N. Hy. O.
978		9	1	16:30	N	48 W	30 N		B	5		U.S.N. Hy. O.
979		10	14	10:30	N	120 W	34 N		-	10	D,C	U.S.N. Hy. O.
980		11	14	13:57	N	2 W	37 N	Leonid	Br	4	C,P	Marine Obs. 8,229,1931
981		11	15	14:30	N	6 W	55 N	Leonid ??	F	Sev.		Nat. 126,969,1930
982		11	16	12:03	N	36 W	53 N		B	13	L,P,E	Marine Obs. 8,229,1931
983		11	16	13:45	N	114 W	26 N	Leonid ??	Br	45	Y	U.S.N. Hy. O.
984		11	16	13:47	N	81 W	24 N	Leonid	?	16	D,C	U.S.N. Hy. O.
985		11	16	14:28	N	75 W	19 N	Leonid	-4	2	Y	U.S.N. Hy. O.
986		11	16	14:30	N	69 W	30 N	Leonid	?	0.7	D	U.S.N. Hy. O.
987		11	16	14:54	N	82 W	24 N	Sp.	?	10	D,R	U.S.N. Hy. O.
988		11	16	15:1"	N	84 W	26 N	Leonid	B	1	B	U.S.N. Hy. O.
989		11	16	15:15	N	92 W	42 N	Leonid ?	Br	10		P.A. 38,623,1930
990		11	16	15:17	N	39 E	45 N	Leonid	-9	6	D,P,S	V.Fedyuskiu report
991		11	16	15:28	N	143 W	28 N	Leonid	Br	6	Y	U.S.N. Hy. O.
992		11	16	15:35	N	85 W	26 N	Leonid ??	B	Long	L	U.S.N. Hy. O.
993		11	16	15:43	N	74 W	23 N	Leonid	B	25	D	U.S.N. Hy. O.
994		11	16	16:08	N	92 W	42 N	Leonid ??	Br	10	D	P.A. 38,623,1930
995		11	16	16:32	N	61 W	43 N	Leonid ?		Sev. *	S,P	Marine Obs. 8,228,1931
996		11	16	17:23	N	102 W	17 N	Leonid	Br	3	E,S	U.S.N. Hy. O.

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
997		12	14	14:03	N	77 W	22 N		?	10		U.S.N. Hy. O.
998	1931	2	5	8:55	N	86 W	42 N		F,B	1.5	Y	P.A. 39,223,1931
999		3	25	22:45	D	100 W	39 N		B	Some		Newspaper reports
1000		3	29	9:42	N	43 E	53 N		-	30-	C,P	Kondratiev report
1001		4	21	13:14	N	74 W	21 N	Lyrid	B	4	C	U.S.N. Hy. O.
1002		5	16	12:21	T	87 E	54 N		Br	15	Y,L,P	Petrov report
1003		6	3	12:30	N	74 W	40 N		¼ M	0.5	D	P.A. 39,605,1931
1004		6	10	8:14	T	77 W	43 N		B	20	Y,S	12 or more A.M.S. reports
1005		7	12	10:	N	123 W	44 N		<Br	5	D	P.A. 39,605,1931
1006		7	18	3:10	D	97 W	33 N		B	15	Z,L	Tex.O.B. No.29,1934
1007		8	4	7:55	T	92 W	43 N		Br	50 *	D,S,P	W.C.Alvarez letter
1008		8	8	11:50	N	62 W	11 N		F,B	12.5	S	Marine Observer 9,151,1932
1009		8	15	9:36	N	46 W	44 N		Br	2 +	B	U.S.N.Hv. O.
1010		9	17	12:22	N	54 E	5 S		Br	15-		Obs. 54,342,1931
1011		9	27	6:21	T	44 E	13 N			9	M,S,P	Marine Obs. 9,182,1932
1012		10	9	12:20	N	74 W	20 N		B	1.2		U.S.N. Hy. O. (2 Ships)
1013		10	18	9:30	N	90 W	43 N	Orionid ?	Br	15	Y	U.S.N. Hy. O.
1014		11	3	10:00	N	4 E	49 N		-	25	D,S	B.S.A.F. 45,512,1931
1015		11	5	11:25	N	11 E	50 N		?	14 *	D,L,P	C. Hoffmeister letter
1016		11	13	14:10	N	11 E	50 N	Leonid	-3	10+ *	D,L,P	C. Hoffmeister letter
1017		11	15	13:18	N	118 W	34 N	Leonid		1.5		A. M. Brayton report
1018		11	15	13:32	N	118 W	34 N	Leonid		2		A. M. Brayton report
1019		11	15	13:57	N	118 W	34 N	Leonid		4.5		A. M. Brayton report
1020		11	15	14:51	N	107 W	17 N	Sp.	?	2.5	Z,S	U.S.N. Hy.O.
1021		11	15	15:05	N	37 W	53 N			5	Z,L	Marine Obs. 9,201,1932
1022		11	15	17:16	N	99 W	33 N	Leonid	-7	22*	D,P	O.E.Monnig report
1023		11	16	12:05	N	118 W	34 N	Leonid		1.5		A. M. Brayton report
1024		11	16	12:05	N	118 W	34 N	Leonid		1.5		A. M. Brayton report
1025		11	16	12:37	N	74 W	27 N	Leonid	2/3 M	20	D	U.S.N. Hy. O.
1026		11	16	13:07	N	152 E	26 N	Leonid	Br	8.2	C,B	U.S.N. Hy. O.
1027		11	16	13:37	N	59 W	25 N	Leonid ?	?	4	D,S	U.S.N. Hy. O.
1028		11	16	13:47	N	118 W	34 N	Leonid		5		A. M. Brayton report
1029		11	16	13:52	N	76 W	43 N	Leonid	Br	6	D,C	C. R. Gregory report
1030		11	16	13:53	N	74 W	42 N	Leonid	-3	5	Y,P	C. P. Olivier report
1031		11	16	14:02	N	118 W	34 N	Leonid	Br	11	R	C. W. Thompson report
1032		11	16	14:10	N	99 W	19 N	Leonid ?	Br	5		J. Gallo letter
1033		11	16	14:14	N	74 W	42 N	Leonid	-2	12*	D,P	C. P. Olivier report
1034		11	16	14:15	N	131 W	48 N	Leonid	Br	9	L	U.S.N. Hy. O.
1035		11	16	14:18	N	128 W	29 N	Sp.	S	7	D	U.S.N. Hy. O.
1036		11	16	14:19	N	37 W	53 N		F,B	14*	M,R	Marine Obs. 9,201,1932
1037		11	16	14:20	N	100 W	16 N	Leonid	Br	3	D,C	U.S.N. Hy. O.
1038		11	16	14:26	N	37 W	16 S	Leonid	Br	3 +		Marine Obs. 9,201,1932
1039		11	16	14:28	N	93 W	14 N	Leonid ??	?	5	S	U.S.N. Hy. O.
1040		11	16	14:45	N	77 W	43 N			1.5		K. Gell report
1041		11	16	14:52	N	95 W	14 N	Sp. ??	?	10	D	U.S.N. Hy. O.
1042		11	16	15:10	N	99 W	19 N	Leonid	Br	15	D	J. Gallo letter
1043		11	16	15:24	N	39 W	55 N	Leonid	B	6	D,C	Marine Obs. 9,201,1932
1044		11	16	15:25	N	63 W	33 N		Br	25	D,S	U.S.N. Hy. O.
1045		11	16	15:27	N	93 W	15 N		?	2	C	U.S.N. Hy. O.
1046		11	16	15:55	N	77 W	43 N	Leonid	Br	3.5		K. Gell report
1047		11	16	16:01	N	74 W	42 N	Leonid	?	10 *	D,L,P	Proc. Am. Phil. Soc. 72,225,1933
1048		11	16	16:02	N	77 W	42 N			12		K. Gell report
1049		11	16	16:12	N	82 W	30 N	Leonid	Br	15	C,P	M.R. Ensign report
1050		11	16	16:15	N	74 W	42 N	Leonid	0	1	Y	C. P. Olivier report
1051		11	16	16:15	N	77 W	42 N			20		K. Gell report
1052		11	16	16:45	N	77 W	42 N			10		K. Gell report
1053		11	16	16:48	N	79 W	36 N			3.5		J.C. Swanson report
1054		11	16	16:53	N	79 W	36 N			4.8		J.C. Swanson report
1055		11	16	16:59	N	74 W	42 N	Leonid	?	1	Y	C. P. Olivier report
1056		11	16	17:06	N	79 W	36 N			3.0		J. C. Swanson report
1057		11	16	17:12	N	131 W	49 N	Leonid ?	B	10	D,R	U.S.N. Hy. O.
1058		11	16	17:22	N	82 W	30 N	Leonid	?	1.5	Y,P	M. R. Ensign report
1059		11	16	17:25	N	82 W	30 N	Leonid	?	1.7	Y,P	M. R. Ensign report
1060		11	16	17:29	N	74 W	42 N	Leonid	0	3	S	C. P. Olivier report
1061		11	16	17:50	N	82 W	30 N	Leonid	?	1.5	Y,P	M. R. Ensign report
1062		11	16	18:	N	86 W	42 N			2		W. J. Persons report

NO.	DATE Y	M	D	HOUR	TYPE	λ φ (° °)	RADIANT α δ (° °)	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
1063	1931	11	17	14:14	N	148 E 24 N	Leonid	?	5.5+	C	U.S.N. Hy. O.
1064		11	17	14:26	N	37 W 16 S	Leonid	Br	4-		Marine Obs. 9,201,1932
1065		11	17	16:26	N	121 E 25 N	Leonid	?	9	M	Kwasan Bul. No. 233
1066		12	1	18:36	T	79 W 37 N	169 + 34	Br	60+	D,S	Proc.Va.Ac.Sci.31,1931-2
1067		12	8	14:00	N	80 W 28 N	Sp	-4	1	S	U.S.N. Hy. O.
1068		12	31	12:02	N	8 E 52 N	51 - 28	-3	Sev.		A.N. 257,5,1935; etc.
1069	1932	1	2	14:28	N	118 W 32 N		Br	24	D,C,P	P.V.Stump report: U.S.N.Hy.O. (2 Ships)
1070		2	14	13:51	N	62 W 19 N		B	3	Y	U.S.N. Hy. O.
1071		3	3	-	N?	22 W 56 N		?	10		U.S.N. Hy. O.
1072		4	5	9:14	N	120 W 32 N	245 + 38	Br	37	M	Reports from 3 Ships : U.S.N.Hy.O
1073		4	6	9:00	N	123 W 32 N		B	2		U.S.N. Hy. O.
1074		5	3	17:12	N	139 E 35 S	Eta Aq.	1	3	D,P	R. C. Shinkfield report
1075		6	4	11:57	N	84 W 41 N		> M	10	D	P.A. 40,416,1932, and letter
1076		7	5	11:50	N	20 W 12 N		Br	5		U.S.N. Hy. O.
1077		7	29	7:52	T	75 W 40 N		-3,B	3	L	2 reports
1078		8	10	4:30	D	94 W 38 N	Sp.	F,B	20-	L	P.A. 44,93,1936 and reports; stone
1079		8	10	8:22	T	0 52 N	Perseid		0.5	Y	Obs. 56,35,1933
1080		8	11	15:10	N	81 W 33 N	Perseid	-4	1.5	M	W.P. Wamer report
1081		9	21	17:25	T	122 W 44 N	42 + 50	½M,B	15	S	P.A. 46,274,1938
1082		10	17	14:16	N	83 W 24 N	Sp.	?	3		U.S.N. Hy. O.
1083		11	14	14:45	N	84 W 36 N		?	1		Miss A. Williams report
1084		11	15	13:00	N	72 W 42 N	Leonid	-2	1.3		Annals H.C.O. 82,151,1935
1085		11	15	13:01	N	104 W 18 N	Leonid	-5	1		U.S.N. Hy. O.
1086		11	15	13:07	N	76 W 39 N	Leonid	0	0.5	D	Proc. Am. Phil.Soc.72,225,1933
1087		11	15	14:08	N	76 W 39 N	Leonid	-3	9	D,B,P	Proc. Am. Phil.Soc.72,225,1933
1088		11	15	14:35	N	76 W 39 N	Leonid	-4	9	D,B,P	Proc. Am. Phil.Soc.72,225,1933
1089		11	15	16:05	N	72 W 42 N	Leonid	-3	3	C	Annals H.C.O. 82,151,1935
1090		11	15	16:05	N	98 W 33 N	Leonid	0	3.7	Y	Texas O.B. No.16, and report
1091		11	15	16:15	N	79 W 36 N	Leonid	?	1+	Y	J.C. Swanson report
1092		11	15	16:30	N	100 W 31 N		Br	2	Y	Mrs. F. O. Hester report
1093		11	15	18:	N	74 W 42 N	Leonid	B	2	S	J. A. Kingsbury report
1094		11	16	10:23	N	95 W 39 N	Leonid	X	16+	D,E	E.F. Bowman report
1095		11	16	15:24	N	39 W 55 N	Leonid	Br,B	6	C,D	Marine Obs. 9, -, 1932
1096		11	16	-	N	38 W 45 N		F	5		H. F. Ryan report
1097		11	16	17	N	80 W 26 N		F	8		T. H. Bockhoff report
1098		11	16	17	N	92 W 35 N		F	5	Z ?	A. J. Adams report
1099		12	2	14:14	N	75 W 35 N		Br	8	S	U.S.N. Hy. O.
1100		12	7	7:09	N	80 W 27 N	Sp.	?	1		U.S.N. Hy. O.
1101		12	15	8:24	N	99 W 5 S		- 5	5	Y	U.S.N. Hy. O.
1102	1933	1	2	14:15	N	44 W 32 N	Quad. ?	Br	10	D	U.S.N. Hy. O.
1103		3	23	18:05	T	100 W 36 N	342 + 9	Br	90	D,S,P,E	P.A. 43,291,1934; Proc.Am. Phil. Soc. 75,486,1935; stone
1104		5	1	15:05	N	47 W 37 N		Br	15	R,P	Marine Obs. 11,50,1934
1105		5	5	14:34	N	69 E 39 N		Br	13		I. S. Artapowitsch report
1106		5	17	10:16	N	175 E 42 S	154 -14	B	5	C,Y	J.B.A.A. 45,74,1934
1107		7	27	9:	N	41 W 34 N		Br	1.7		Marine Obs. 11,95,1934
1108		8	21	8:05	N	84 W 36 N	279 + 65	> M	3.4	D,B	M.W.R. 61,326,1933; Flower Obs. Rep. 23
1109		9	21	8:38	N	69 E 39 N		-4	1.8 *	D,C,P	I.S.Astapowitsch report
1110		9	27	13:35	N	64 W 32 N		Br	13	D,C	U.S.N. Hy. O.
1111		10	7	7:17	N	69 E 39 N		-	8.5 *	Z,B,P	I.S.Astapowitsch report
1112		10	9	7: -	N	1 E 46 N	Drac.	Br	3 *	D	B.S.A.F. 47,509,1933
1113		10	9	7:35	N	2 E 49 N	Drac.	Br,B	20+ *	S.P	B.S.A.F. 47,508,1933
1114		10	9	7:45	N	1 E 48 N	Drac.	Br	15	Y,S,P	B.S.A.F. 47,578,1933
1115		10	9	8:29	N	2 E 49 N	Drac.	Br	4 +	D,S,P	B.S.A.F. 47,503,1933
1116		10	9	13:53?	N	69 E 34 N	Drac. ?	0	0.7 *	D,B,P	I. S. Astapowitsch report
1117		10	13	10:48	N	69 E 39 N		Br	4 *	D,R,P	I. S. Astapowitsch report
1118		10	17 ?	10:26	N	69 E 39 N	Orionid	Br	14	D,E,P	I. S. Astapowitsch report
1119		10	19	11:01	N	69 E 39 N	Orionid	-	9 *	D,R,B,P	I. S. Astapowitsch report
1120		11	9	14:55	N	75 W 38 N	Sp.	Br	6		U.S.N. Hy. O.
1121		11	10	17:45	N	80 W 33 N	Sp.	2/3 M	5 +	S	A.W. Beasley letter
1122		11	12	14:40	N ?	69 E 39 N		-	2	Y,P	I. S. Astapowitsch report
1123		11	16	14:06	N	19 W 52 N		Br	15	M	U.S.N. Hy. O.) not same meteor
1124		11	16	14:21	N	16 W 55 N		- 3	?	S	U.S.N. Hy. O.)

NO.	DATE Y	M	D	HOUR	TYPE	λ φ	RADIANT α δ	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
						° °	° °				
1125	1933	12	5	5:03	N	19 E 54 N	Sp.	> 0	9	D	A.N. 251,223,1934
1126		12	16	11:46	N	86 W 26 N	Sp.	Br	8	L	U.S.N. Hy. O.
1127	1934	5	5	14:47	N	93 W 28 N	Sp.	Br	13	M,C	U.S.N. Hy. O.
1128		5	11	16:26	N	75 E 10 N	Eta Aquarid	Br	3	D,S,P	U.S.N. Hy. O.
1129		6	5	P.M.	N	164 E 79 S		I	0.1*	D	T.C.Poulter report
1130		6	17	18:45	N	164 E 79 S			? *	D	T.C.Poulter report
1131		6	17	18:48	N	164 E 79 S		I	0.1*	D	T.C.Poulter report
1132		7	5	8:23	T	25 E 48 N		Br	24	S,B	A.N. 253,291,1934
1133a		8	10	12:58	N	30 E 60 N		Br	1 ?	S	A. Kokhanov report) same
1133b		8	10	15:58	N	30 E 60 N	Perseid	-9	1.5*	S	V. Petrov report) meteor ??
1134		8	11	8:25	N	91 W 38 N		-7	5 *	D,C,P	J.W.Simpson report
1135		8	11	9:46	N	70 W 44 N	Perseid	-5	22	D,B,P	R.M. Dole report
1136		8	11	12:16	N	30 E 60 N		Br	5	S	A. Manotskov report
1137		8	11	12:45	N	15 E 49 N	Perseid	-5	6	D,P	P.A. 42,510,1934, B.S.A.F. 49,201 + 289,1935
1138		8	12	12:	N	50 E 70 N	Perseid	-2	3	D,P	N. Gurlev report
1139		9	4	12:	N	50 E 70 N		-1	0.4*		N. Gurlev report
1140		9	6	7:20	N	100 W 36 N		Br	10		P.A. 42,518,1934
1141		10	3	17:50	T	39 E 5 S		Br	5	D,S	U.S.N. Hy. O.
1142		10	6	10:40	N	118 W 34 N		Br	2+	D,C	U.S.N. Hy. O.
1143		10	8	8:17	N	74 W 20 N		Br	20	C	U.S.N. Hy. O.
1144		10	8	9:04	N	77 W 22 N		B	2.5		U.S.N. Hy. O.
1145		10	11	10:29	N	0 W 54 N	250 + 75	> M	3	D,E,P	Nat. 134,1004,1934
1146		10	13	11:58	N	69 E 39 N	Sp.	- 2	5.2*	D,S	I. Astapow tsch report
1147		10	18	14:29	N	148 E 22 N		Br	2.6		U.S.N. Hy. O.
1148		10	29	7:17	N	75 W 40 N		1/3 M	3.2	Y	A. Johnson report
1149		11	5	7:16	N	43 E 13 N		Br	11	R,P	Marine Obs. 12,147,1935
1150		11	11	12:56	N	84 W 25 N		M,B	8	C	U.S.N. Hy. O.
1151		11	16	15:34	N	136 E 35 N	74 + 31	-5	0.8	D,R,P	H. Inouye report (2 observers)
1152		11	16	17:14	N	140 E 35 N	Leonid	-4	2		Kwasan Obs. Bul. 3,298,1935
1153		12	4	13:16	N	27 W 12 N		B	2 ?		U.S.N. Hy. O.
1154	1935	1	4	13:00	N	38 E±22 N			3	S,P	Marine Obs. 13,99,1936
1155		2	27	6:08	T	78 W 40 N	80 + 46	-5	12+	D,S	M.W.R. 63,158,1935; Flower Obs.
1156		3	24	7:05	T	10 E 55 N		Br	25	D,S,Ph.	A.N. 255,153,1935: Nat.136, 224,1935
1157		5	20	12:36	N	85 W 21 N		-5,B	8		U.S.N. Hy. O.
1158		5	27	10:20	N	123 W 46 N		Br	>1*	S	U.S.N. Hy. O.
1159		6	9	7:39	T	97 W 35 N		< M	40	D,S,P	Tex Obs. Bul. No.57 and reports
1160		6	27	14:00	N	69 E 39 N		+ 1	2.2	D,R	N. Gurlev report
1161		7	7	-	N	69 E 39 N		-	?	D	N. Gurlev report
1162		7	10	11:18	N	75 W 40 N		-6	10-	K,C	5 reports to A.M.S.
1163		7	9	15:05	N	69 E 39 N		+ 2	0.8 *	D,P	N. Gurlev report
1164		7	11	14:45	N	73 W 41 N		B	1		C.A. Isterholm report
1165		7	22	12:04	N	136 E±36 N		-	3.8	D,P	Kwasan Obs. Bul. 4,311,1936
1166		7	30	13:37	N	69 E 39 N		+ 1	1.3*	D	N. Gurlev report
1167		7	31	8:30	T	79 W 44 N		- 4	10	D,S	Jour.R.A.S.Can. 29,329,1935; report
1168		8	5	13:02	N	69 E 39 N		-	0.8 *	D,P	N. Gurlev
1169		8	18	12:26	N	30 E 60 N		0	0.3	D,E	V.N.Petrov report
1170		9	6	13:56	N	70 W 28 N		- 2	9	M,L	U.S.N. Hy. O.
1171		9	17	19:46	N	119 W 36 N		½M,B	1	Y	U.S.N. Hy. O.
1172		9	27	7:32	N	78 W 13 S		- 5	30 *	S	U.S.N. Hy. O.
1173		10	3	9:00	N	16 W 25 N		0 B	Sev.	Y	Marine Obs. 13,132,1936
1174		10	20	11:57	N	69 E 39 N		+ 1	2.1 *	D,P	N. Gurlev report
1175		10	24	7:17	N	3 E 40 N		- 6	20 *	D,R	A.N. 257,251,1935
1176		10	27	10:11	N	69 E 39 N		+ 1	9.5*	D,P	N. Gurlev report
1177		11	13	5:05	T	12 E 10 S			21	D,S	Marine Obs. 13,132,1936
1178		11	18	14:39	N	75 W 40 N	Leonid	< Br	1.5	D,C,P	R.S.Whitney report
1179		11	28	16:37	N	14 W 39 N		B	4.5	M	U.S.N. Hy. O.
1180		12	16	10:40	N	69 E 39 N		+1	1.5 *	D,P	N. Gurlev report
1181		12	21	10:42	N	81 W 24 N		B	10	D,C,P	U.S.N. Hy. O.
1182	1936	4	21	14:19	N	12 E 44 N	Lyrid	-10	2.5*	D,S,P	E. Loreta report; Jour.R.A.S.Can. 30,250,1936
1183		7	21	11:28	N	63 E 36 N		-	61*	D,S,P	N. Gurlev report
1184		7	23	12:00	N	13 E 51 N	23 + 30	-14	30+	D,P	A.N.261,345,1936; Die Sterne 16,203,1936

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α δ ° °	MAX. MAGN.	DUR-ATION	MOTION OF TRAIN	REFERENCES
1185	1936	7	26	10:36	N	63 E	36 N		-	1.1	D,S,P	N. Gurlev report
1186		7	28	9:04	N	12 E	44 N	Sp.	- 4	1.7*	D,C,P	Jr. R.A.S. Can. 30,369,1936
1187		8	9	8:50	N	63 E	36 N		-	4.1	D,B,B,P	N. Gurlev report
1188		8	10	15:34	N	70 W	14 N	Perseid ?	Br	2	Y	U.S.N. Hy. O.
1189		8	11	12:22	N	99 W	30 N	Perseid	- 4	5	D,B	R.H. Wilson report
1190		8	11	12:02	N	63 E	36 N		-	1.2	D,P	N. Gurlev report
1191		8	11	12:53	N	63 E	36 N		-	1.2*	D,P	N. Gurlev report
1192		8	11	14:23	N	63 E	36 N		-	2.2		N. Gurlev report
1193		8	11	14:59	N	63 E	36 N		-	1.2		N. Gurlev report
1194		8	12	9:28	N	63 E	36 N		-	.4		N. Gurlev report
1195		8	12	13:15	N	63 E	36 N		-	8.8		N. Gurlev report
1196		8	12	12:35	N	87 W	36 N	Perseid	< M	0.7	C,D	L.J.Wilson report
1197		8	13	9:25	N	63 E	36 N		-	0.6		N. Gurlev report
1198		8	13	14:36	N	12 E	44 N	Perseid	0	0.8*	D,C,P	Jr. R.A.S. Can. 30,369,1936
1199		8	13	15:37	N	12 E	44 N	Sp.	- 1	1.2*	D,C,P	Jr. R.A.S. Can.30,369,1936
1200		8	14	10:14	N	63 E	36 N		-	6.3		N. Gurlev report
1201		8	17	7:12	T	98 W	34 N		F,B	15 +	Y	P.A. 44,568,1936; stones
1202		9	7	7:30	N	63 E	36 N		-	5.6		N. Gurlev report
1203		9	11	8:10	N	63 E	36 N		-	7		N. Gurlev report
1204		9	13	14:39	N	63 E	36 N		-	3.3		N. Gurlev report
1205		9	15	12:21	N	11 E	50 N		-5	8 *	D,C,P	Hoffmeister report
1206		9	16	13:16	N	11 E	50 N		-1	10 *	D,B,P	Hoffmeister report
1207		9	20	12:10	N	10 W	1 S		Br	13+	D	U.S.N.Hy.O
1208		10	18	5:23	N	69 E	39 N		- 1			N. Gurlev report
1209		10	18	14:31	N	70 W	44 N	Orionid	-6,B	2.2	D,B,P	R.M. Dole report
1210		10	19	11:53	N	89 W	43 N	Orionid	B	7		Amat. Astr. 2, 142
1211		10	19	14:17	N	70 W	20 N	Orionid??	Br	4	D,C	U.S.N. Hy. O.
1212		10	21	11:05	N	80 W	30 N	Sp.	<F	10	D	Dearborn report
1213		10	21	11:34	N	21 E	52 N	Orionid ?	-3	7 *	L	Acta Astr. 3,38,1937
1214a		10	21	14:36	N	87 W	26 N	Orionid	Br	11		U.S.N. Hy. O.)same
1214b		10	21	14:49	N	85 W	26 N		Br	5	C,M	Marine Obs. 14,143,1937)meteor?
1215		10	22	11:03	N	12 E	44 N	Orionid	-2	6 *	D,S,P	E. Loreta report
1216		10	22	11:58	N	61 W	24 N	Orionid	Br	30	D,C	U.S.N. Hy. O.
1217		11	16	11:03	N	12 E	44 N	Leonid	-4	5 *	D,C,P	E. Loreta report
1218		11	16	14:44	N	81 W	29 N	Sp.	-2	3.5	D	R.F. Stevens report
1219		11	24	15:40	N	11 E	50 N		-3	15 *	D,C,P	C. Hoffmeister report
1220		12	6	13:59	N	30 E	34 N		Br	11	D,C	U.S.N. Hy. O.
1221		12	22		N	21 E	52 N	171 + 16	Br	0.8		Acta Astr. 3,119,1937
1222	1937	1	19	6:04	T	72 W	21 N		Br,B	20	D,S,P	Marine Obs. 15,10,1938
1223		2	7	14:16	N	46 W	31 N		M	12	M	U.S.N. Hy. O.
1224		3	21	6:52	T	3 W	51 N		?	8	D,P	Jour.B.A.A. 47,255,1937
1225		5	30	15:09	N	66 W	30 N		Br	3		U.S.N. Hy. O.
1226		6	20	8:33	T	98 W	36 N		>V	10-	D,S	S. Burch report
1227		6	21	7:41	T	117 W	33 N		Br	32	D,C,P	O. B. Landau report
1228		6	21	7:50	T	97 W	33 N		> M	20+	D,C	Texas O.B. 2,83,1938
1229		6	23	8:25	T	79 W	44 N		-5,B	30	D,S	A. Davidson report
1230		8	3	12:57	N	11 E	44 N	Perseid	0	1.5*		Jour.R.A.S. Can. , 32,91,1938
1231		8	7	14:31	N	37 E	22 N	Perseid???	Br	5	D,R,P	Marine Obs. 15,90,1938
1232		8	8	10:08	N	30 E	60 N	Perseid	- 8	2.5	Y,E,P	V.N.Petrov report
1233		8	9	10:48	N	11 E	44 N	335 + 67	- 2	0.4 *	Y	Jour.R.A.S. Can. 32,91,1938
1234		8	11	11:30	N	11 E	54 N	Perseid	- 4.5	3 *	Z,S	Die Sterne, 17,237,1937
1235		8	12	12:14	N	122 W	37 N	Perseid	- 3	1 *	D,C,P	L. Arstanian Report
1236		8	13	12:02	N	77 W	43 N	Perseid	-3	1.5	D?,S	C.H.Smith report
1237		8	17	11:31	N	90 W	39 N	Sp.	0	20	D	Jour.R.A.S. Can. 31,398,1937
1238		9	11	11:45	N	30 E	60 N		-4.5	0.7	M	V.N.Petrov report
1239		9	26	7:58	N	4 E	51 N		Br	6*	D,C	Astr.Gaz.24,99-100; 1937
1240		10	4	11:10	N				X,Br	6.5	S	Marine Obs. 15,139,1938
1241		10	30	8:25	N	21 W	49 N		B	5		U.S. W.B. report
1242		10	30	10:06	N	78 W	31 N		Br	15	D	U.S.N. Hy. O. 2522; 1938-1-5
1243		10	31	14:48	N	147 E	32 N		Br	9	D,C	U.S.N. Hy. O.
1244		11	3	7:22	N	58 W	19 N		-3	4	D,S	U.S.N. Hy. O.
1245		11	6	11:42	N	145 E	27 N		-4,B	0.9	S	U.S.N. Hy. O.
1246		11	12	16:40	N	12 E	44 N	Sp.	-10	11*	D,S,P	E. Loreta report
1247		12	13	15:50	N	93 W	14 N		- 3	4	D,C,P	U.S.N. Hy. O.; M.D. Berg report
1248		12	18	11:17	N	45 W	31 N		?	11	E,S,P	U.S. W.B. report

NO.	DATE Y	M	D	HOUR	TYPE	λ °	φ °	RADIANT α ° δ °	MAX. MAGN	DUR-ATION	MOTION OF TRAIN	REFERENCES
1249	1938	2	7	5:50	T	79 W	36 N		> M	5+	D	A.C.Howell report
1250		2	18	8:13	N	37 E	23 N		B	2	Y	Marine Obs. 16,11,1939
1251		3	5	13:54	N	84 W	25 N		B	3-	D,C	U.S.N. Hy. O.
1252		6	1	7:50	T	117 W	49 N	167 + 13	M >,B	60+	D,B,B,P	48 reports to A.M.S.
1253		6	24	5:40	D	80 W	41 N		M,B	15-	D	
1254		7	25	10:11	N	12 E	44 N		-3	5*		E. Loreta report
1255		7	28	11:46	N	12 E	44 N	Perseid	0	0.3*	P	E. Loreta report
1256		7	29	12:28	N	118 W	48 N		1/8 M	5	Z,P	B.C. Parmenter report
1257		10	21	13:35	N	12 E	44 N	Sp.	±1	0.5*		Jour. R.A.S. Canada 33,114,1939
1258		10	22	13:52	N	104 W	18 N		-5	1.3*	C	U.S.N. Hy. O.
1259		10	26	12:50	N	88 W	16 N		-5	3.5	C	U.S.N. Hy. O.
1260		10	27	7:55	N	81 W	29 N		-4,B	Sev.	Z	D. Faulkner report
1261		11	21	14:12	N	111 W	23 N		Br	1+	S	U.S.N. Hy. O. 2575
1262		11	20	17:42	N	9 E	49 N	160 + 45	-6	25	D,E	A.N. 269, 276-8; 1939
1263		11	24	15:43	N	15 E	43 N		Br	25	D,E	U.S.N. Hy. O.
1264	1939	1	11	14:02	N	79 W	12 N	170 - 19	-5	7	D,P	P.A. 47,204,1939
1265		4	16	15:30	N	57 W	12 N		+3,B	4.8	C,E,D	U.S.N. Hy. O.
1266		4	22	9:45	N	74 W	41 N	Sp.	F	7+	D	M.Preis report
1267		4	28	22:20	D	87 W	32 N		X	Sev.	M	P.A.48,93,1940; The Sky June, 1940, p.6
1268		5	2	7:01	T	96 W	29 N		F	15	S,Y	The Sky Aug. 1939, p.6; stones
1269		5	15	9:05	N	74 W	41 N		X	10+	D,P	F.W.Smith report
1270		Summer		-	-	116 W	48 N		F	30	Y	Wm.Tessin report
1271		7	16	10:00	N	11 E	44 N	Perseid ?	-2	2.5	D,C,P	Jour.R.A.S.Canada 33,388,1939
1272		7	16	11:23	N	126 E	31 N		Br,B	2	Y	U.S.N. Hy. O.
1273		8	9	16:15	N	81 W	40 N	Perseid??	-	15	S,P	W.A.Dietrich report
1274		8	12	13:30	N	11 E	44 N	Perseid	-3	7.5*	D,P	Jour.R.A.S.Canada 33,390,1939
1275		8	12	14:07	N	11 E	44 N	Perseid	+1	0.5*	D,P	Jour.R.A.S.Canada 33,390,1939
1276		8	15	9:55	N	11 E	50 N	Perseid	X	17	D,R,P	Die Sterne 19,242,1939
1277		8	16	15:50	N	43 W	24 N	Perseid??	-3	3.5	M	U.S.N. Hy. O.
1278		9	11	13:16	N	79 W	28 N		F	??	D	U.S.N. Hy. O.
1279		9	14	9:35	N	90 W	42 N		½ M	6	D,P	P.J.Klaas report
1280		9	16	9:29	N	90 W	28 N		B	0.8*	S	U.S.N. Hy. O.
1281		10	6	14:57	N	61 W	18 N		-3	3.5	C,D	U.S.N. Hy. O.
1282		10	8	11:01	N	113 W	37 N		-	2.5	S	E.A.Kinoatek report
1283		10	19	14:59	N	85 W	25 N		F,B	20	D	U.S.N. Hy. O.
1284		10	19	16:25	N	85 W	21 N		-	10	D	U.S.N. Hy. O.
1285		10	20	12:22	N	11 E	44 N	Orionid	-5	6*	D,C,P	Jour.R.A.S.Canada 33,441,1939
1286		10	20	13:44	N	11 E	44 N	Orionid	0	1*	D,P	Jour.R.A.S.Canada 33,443,1939
1287		10	20	16:24	N	11 E	44 N	Orionid	-7	2.3*	D,S,P	Jour.R.A.S.Canada 33,443,1939
1288		10	21	16:18	N	79 W	45 N	Orionid	-3	3*	D,P	Jour.R.A.S.Canada 33,439,1939
1289		10	22	15:06	N	10 E	43 N	Orionid	-1	1.3*	P	Mme. Corucci report
1290		11	8	10:08	N	11 E	44 N		-2	3.2*	D,C,P	Jour.R.A.S.Canada 33,443,1939
1291a		11	16	14:28	N	70 W	44 N	Leonid	M	41	D,P	R.M.Dole report) same
1291b		11	16	14:19	N	79 W	45 N	Leonid	-3+	5.5*	D	Jour.R.A.S.Canada,33,439) meteor 1939:34.425.1940
1292		11	16	16:30	N	79 W	45 N	Leonid	-3	9*	D,P	Jour.R.A.S.Canada 33,439,1939
1293		11	16	17:04	N	81 W	40 N		X	1+	Z	Wm.A.Dietrich report
1294	1940	3	22	7:22	T	83 W	42 N		Br	15	D,C,P	Mrs.M.Back report
1295		4	2	14:07	N	88 W	22 N		B	5	-	U.S.N. Hy. O.
1296		4	20	15:52	N	81 W	29 N	Sp.	-6	0.3	D,S,P	A.E.Hayes report
1297		8	11	13:03	N	12 E	44 N	Perseid	-2	0.8*	D,P	E.Loreta report
1298		8	12	13:53	N	12 E	44 N	Perseid	0	2.2*	D,P	E.Loreta report
1299		8	12	14:57	N	12 E	44 N	Perseid	-2	2.2*	D,P	E.Loreta report
1300		8	14	15:37	N	12 E	44 N	Perseid	-2	2.3*	D,P	E.Loreta report
1301		9	11	14:56	N	84 W	25 N		F	1+	Y	U.S. W.B. report
1302		10	21	15:17	N	91 W	28 N	Orionid	-	1.5	D,C	U.S.N. Hy. O.
1303	1941	1	9	18:12	N	73 W	38 N		F,B	2	M	U.S.N. Hy. O.
1304	1850	10	3	8:30	N	73 W	42 N		F	60?	A ?	A.A.A.S. Proc. 6,191,1851
1305	1862	9	-	P.M.	?	0	46 N		F,B	Long		L'Espace Celeste
1306	1865	2	10	-	-	78 E	12 N		M,B	5		Astr. Reg. 3,162,1865
1307	1868	6	8	9:50	T	1 W	52 N		Br	4	S	Eng.Mech.7,351,1868
1308	1871	10	18	9:45	N	8 W	48 N		Br	15 -	C	Astr. Reg. 9,18,1871
1309	1873	2	3	9:45	N	145 E	38 S		-4	5	D	Eng.Mech.17,171,1873
1310	1882	2	3	3:45	D	23 E	47 N		F,B	Long		Stones,Wien.A.K.89,11,283,1914; H.C.45;

NO.	DATE Y	M	D	HOUR	TYPE	λ	φ	RADIANT α	δ	MAX. MAGN.	DURATION	MOTION OF TRAIN	REFERENCES
						°	°	°	°				
1311	1892	8	9	10:00	N	2 W	54 N			1/4M,B	1		Eng.Mech.55,600,and 56,12,1892
1312	1893	11	4	11:	N	2 W	56 N			M	2	K	Eng.Mech.58,263,and 509, 1893
1313	1896	5	6	10:45	N	2 W	53 N			M	1	C	Eng.Mech.63,279,1896
1314	1896	6	3	15:34	N	1 W	53 N			M	2	Y	Eng.Mech.63,374,1896
1315	1899	11	14	16:51	N	2 W	52 N	Leonid		F	3	D,B	Mem.B.A.A. 9,I, 13, 1901
1316		11	15	16:47	N	0	52 N	Leonid		-3	2	Y	Mem.B.A.A. 9,I, 11, 1901
1317	1908	1	4	10:45	N	3 W	51 N			Br	0.5	D	Eng.Mech.86,519,1908
1318		2	7	10:31	N	1 W	54 N			Br,B	2		Eng.Mech.87,37,1908
1319	1909	8	12	9:25	N	1 E	52 N			Br	5		Eng.Mech.90,66,1909
1320	1911	5	03	8:49	N	2 W	54 N			-4,B	1	Y	Eng.Mech.93,335,1911
1321		12	17	5:	D	31 E	32 N			B	Long	C	Nat.88,449,1911-12
1322	1912	3	6	7:36	N	7 W	55 N			F	Sev.	Y	Eng.Mech.95,157,1912
1323	1915	10	29	7:15	N	45 E	13 N			F	10	C	B.S.A.F. 30,51,1916
1324	1917	4	29	-	-	10 E	35 N			-	5	Y	B.S.A.F. 31,246,1917
1325	1921	9	23	18:47	T	44 E	12 N			F,B	3.6	Y	B.S.A.F. 36,107,1922
1326	1928	8	19	10:23	N	19 E	54 N			-2	0.8	D,C	A.N.241.197.1931
1327		11	15	14:	N	82 W	29 N	Leonid		Br	3		P.A. 38,105,1929
1328		11	15	14:	N	82 W	29 N	Leonid		Br	5		P.A. 38,105,1929
1329	1930	11	16	14:	N	38 W	45 N			Br	5	K,C	Report from H.F.Ryan
1330		11	16	16: +	N	92 W	34 N			Br	5	Y	Report from A.J.Adams
1331		11	16	17:	N	93 W	35 N			Br	1+	E	Report from H.L.Disheroon
1332		11	16	17:00	N	80 W	26 N			Br	8	Y	Report from T.H.Bockhoff
1333	1931	11	16	-	N	111 W	32 N				10		Sci.N.L. Nov.28,1931
1334		11	16	-	N	111 W	32 N				7		Sci.N.L. Nov.28,1931
1335	1937	6	21	7:44	T	140 E	36 N			-6,B	4	D,C	P.A. 49,198,1941
1336	1941	2	17	18:13	N	116 W	28 N			-3	6	D,C,P	U.S.N. Hy. O.

TABLE II

The first column gives the serial number taken from Table I. Hb gives beginning height and He gives end height of meteor itself in kilometers, the unit everywhere employed. V gives its observed geocentric velocity in km/sec. In Columns 4 and 5, H1 gives height of the upper and H2 of the lower end of the train. Column 6 gives the direction of drift in azimuth, starting at South for 0° and going to West. To get bearings one must add 180°. Vt is the velocity of the drifting train in km/hour. Va is the same velocity expressed in degrees/minute. When the drift was recorded as rapid or slow, without further data, the letters R and S are used in this column. When a double designation, as N/S, appears it means that the direction of motion may be *either* to North or to South, the data being ambiguous. Z denotes that the observer reported no drift of train. Unfortunately, for those which lasted a really long time, there is frequently nothing to show whether the observer meant with respect to the stars, in which case there would be a westward drift due to rotation of Earth, or with respect to Earth's surface, in which case drift would be really zero. I used my best judgment in such cases. The last column gives other data of value as to the train, if available.

With regard to the direction of drift, in the older cases I have usually taken the results of former computers, but often checked them. In some cases I got different results which are entered here, the others being omitted. I am myself responsible for the reduction of all reports to the A. M. S. and those that came from ships, unless the observer himself specifically recorded the direction of drift. Even then, when possible, I checked. This is also true as to Loreta's work and the manuscript reports from the U. S. S. R., both of which are so numerous. I derived all drifts by plotting on a large celestial globe and passing a great circle through the observed points or at observed angle to the meteor's plotted path. Where this circle cuts the horizon was taken as the direction of drift. Hence a drift of 90° means *towards* the West point, not from it. In the 'Remarks' A stands for N. America, S for the oceans, Q for Southern Hemisphere, E for the land-mass of Europe-Asia and a few in N. Africa.

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
22					48	Z?				E
24	118	111	8		111				Height brightest part of train	E
28						135 ±			KI; expanded	E
29						180				E
30						(270			Upper part	E
						(Z			Remainder	
33	190	46		60	46	N/S			Train 52 km long; 14 strata	E
43						315				E
45		24-		93	24-	c 180			Many parallel currents, dif.vel.	A
55						125			Upper part	E
						Z			Lower part	
56						Z?				E
57	(135	88	48			0			von Niessl's values	E
	(78	59	30						Gilbert's values	
59	126									E
63						0?			Smoke: stone meteorite	E
68						270				E
73						cZ				E
75	66	47	64	<66	47>	{ 45			Two parts moving in opposite directions;	A
						{225			no data on which is which	

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
77						180				E
83						45			3 levels	E
87		100							Explosion point	A
93						235		S	Small vertical comp.	A
95						225		S		A
96						NE/SW			Upper part only	A
97						270				A
98						270				A
102	89 +	48				270	300 +			A
115						90		0.7		A
116						Z ±		S	Small deformation	A
127						c 112	151	0.5 +	For 88 km height assumed	A
128						c 112			Slow	E
129						c 135 +				E
134						c 270		0.1	Middle part	S
136						E/W			Contradictory evidence	E
138						c 135		0.2	K2	E
147						Z				E
152						Z			Bent, after 15 min. Z	E
155						45			Z for 7 min., then S W	E
157						Z				A
163	145	92	89					S	Parallel strata; v. low vel.	E
170						Z			Sparks dropped perpendicularly.	E
171	140	16							Particles fell to 16 km; burst at 32 km	E
175						c 11	200	1.2	For 88 km height (assumed?); length train 19 km	A
184						Z +				E
191	96	37	24					S	Certainly small if any	E
194						c 270		0.7		E
195						c 180				E
198						c 202		0.7	For 87 km height; train 24 km long	E
200						{ Z			Upper part	E
						{ 90			Lower part	
201	219	114				c 315			Upward component	E
202	56	13				Z				A
205						270			Middle to E±, rest E/W	E
215						c 270	129 ?	0.4	On assumptions	E
216						c 270			Large drift	E
225	300	16	>58		16	270				A
228						90			Upper level; first had vertical component	E
229						180			"Parts of train"; rapid drift	E
230	88	(16)							Burst at 16 km	Q
232	229	104	94			c 0	579	3.4	von Niessl's values; Denning's vel. for	E
	312	104	86						train; Herchel's values	
235						112			Or opposite; somewhat ambiguous	E
237						Z				E
243						145				Q
245	160	54	67			W/E			Ambiguous	E
247						56			Upper fourth	E
248	39	37	24	(38	38)	180			Several strata	E
252	56	47								E
253						315			At least 3 strata	E
254	56	40							Train in Teles. 24 sec. duration only	E
256						335			Or Z, for middle part	E
260						90				E
263						c Z				E
264						90				E
265	212	59	88						Train 1/7 total length of path	E
266	259	12	30			c 63			Probably middle part	E
274						Z				E
275	282	23	30	37	23	Z +			Train 44 x 2.5 km	E
279	43	37	50	(40	40)					E
284						0				E
285	170	48	109						Middle of train lasted longest	E
286	185	45	39							E

NO.	METEOR Hb	He	V	TRAIN H$_1$	H$_2$	d	Vt	Va	REMARKS	
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
291						180				A
292						180				A
294						180		0.3±	Decreasing vel. in drift, K6	E
295						Z?			Probable interpretation	E
296						90				E
297	58	11								E
298	130	30	42							E
299						225				E
303						315		2.0		E
304						90				E
305					90	?			Vertical component of drift	E
309						c 315	521	2.8	For 97 km height assumed	E
310						c 349	270	2.0	For 80 km height	E
311						c 124	77	0.8	For 97 km height assumed	E
312	160	85		95	85	c 270	180	1.6	Train expanded at rate of 0.16 km/min	E
313						c 0				E
319						c 292				E
321	193	97		105	97	c 180	200		Train expanded at rate of 0.27 km/min	A
322						0				E
323						c 315	274	2.0	For 97 km height assumed	E
325						Z			Or E very slow	E
326				108	98	c 326	338	1.8	Assuming 103 Km alt.	E
328						c 0		1.9		E
334	(115 (137	67 105				90			von Niessl's values, B.A.A.S. values doubtful!	E
341						135				A
342						315		1.8		A
343						315		0.7		A
344						338		0.8		A
345						349			Large drift of 11°	A
346						270		0.6		A
348						180				A
357	148	119	30			270			Slow drift; hopeless disagreement as to results	E
358	126	20							Explosion cloud 2.3 x 1.5 km; Infer Z drift	A
361						315	c 770!	4.0	Very ??; 3 strata	E
362	307	111	88						Inclination of orbit 112°	E
						67	153	0.8	Height assumed? from Haverford, Pa.	A
370	193	79		95	79	(180 (0	< 100 100		Upper part, train 48 km long } from New Lower part } England	
373				(82)					Mean height	A
375				105	84	180				A
377				(124)		180			Brighter portion of the meteor track; train 16 km long	A
382	137	97				(0 {180 (0		1.0	Drifts as seen from New Haven, Conn; from New York, N.Y."to N by E, 5° in 3 min"	A
383						270			Slow; possibly Z ?	A
384					95	180				A
386						Z			Possibly E ?; if so slow	Q
389						0				E
391					(64)	c 180	257?		Vel. due to Denning, who gives d to W; mean height	A
393	145	43	55	76	43	c 135	161	0.6		E
394						180		S		A
395						c 292	137	0.9	Height 88-97 Km assumed; 3 strata	A
396						c 90	48	S	Height 88-97 Km assumed	E
397						c 135	193			E
401						0 ±				E
402	74	82		74	82	45			Deflected upwards at 67 Km! where most persistent part of train was; mean height train 74 Km	E

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
403	166 (83)	16	65	35	16				Train 31 Km long	E
407						c 270	64	0.2	Height 87 Km assumed	E
408	105	32	74	46	44				Train 2° long	E
410	164		> 30			Z			Possibly to W, slow	E
411		69								E
414	145	66		97	77					E
416						180			For center; also vertical component	E
424						Z ±				E
428						90	S		Drift short distance	E
433									Train had vertical component	Q
437	163	32	44	64	32				Train 148 x 0.8 Km	E
438						225 ±			Very uncertain; 9 parallel strata	E
439						45		2		E
446						Z				E
448	192									E
449						c 292	174	0.5	Height 97 Km assumed?	E
452	267	22	26							A
454	142	55								A
455	164	79	29			NW/SE			5 strata	E
456						c 45	319	2.0	Height 105 Km assumed	E
457						c 90	204	1.0	Height assumed?	E
459						c 315				E
460	93	26	24	48	26	c 180		0.9	3 strata	E
463						90		0.3	3 sections	A
466	68	31	34			180		5	Exp. at 35 Km	E
468						c 90			5 strata	E
469						c 180	225	1.9	Height assumed?	E
470						(225	394		Upper part	E
	97	64				(Z	0		Lower part	
471	113	16								A
473						90				A
474	178	44	59						Von Niessl's values	E
	80	32	53						Herschel's values	
479						270				A
481						Z ±				E
489									Several strata	A
490						0		0.5		E
491	122	93	34							E
496						90				A
498						c 225		0.3	Slow	A
501						90			Lower part	A
502						c 0	170	0.5	Assuming average height of ? Km	A
504						c 338	212	0.8	Assuming average height of ? Km	A
505						c 160		0.2		A
506						c 270	373	0.5	Assuming average height of ? Km	A
507						Z			Or N.W.; ambiguous	A
508						23				A
509						90		0.2		E
510						Z			Or to E, very slow	A
511						281		1.7		A
512						225/45			Strata 1,3,5 to N.E.; 2,4,6 to S.W.	E
520						315			Several degrees	A
521						180		S		A
528						c 315 ±				E
531					100	N/S			Mean height	E
532						(45			Upper part	E
						(225			Lower part	
537						Z ±			Very slow	Q
538						180				E
545	105	45		76	69					E
547	133	3	40			158			Burst at 34 Km	E
548						Z?				A
553	220	33	48	40	33	c 225	200		Train 21 Km long	E

NO.	METEOR Hb	METEOR He	METEOR V	TRAIN H_1	TRAIN H_2	TRAIN d	TRAIN Vt	TRAIN Va	REMARKS	
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
554						NW/SE				A
556	126	76		95	76				Train 29 Km long	E
560	105	60		92	72	c 315	290		Train 24 Km long	E
561						Z			Expansion only	E
562						270				E
567	157	40	54	77	39					E
569						c 315	290	1.0	Height assumed ?	E
579						c 23			Different velocities indicated	E
						(Z				
580						(158	48	0.5	Middle part;	E
						(Z				
582						c 202	463	3.4		E
583						Z			At point of appearance	E
588	257	43	81	133	59				Train 634 Km long	E
590				(93)		c 248	201		Mean height given ±	E
594						315		0.2		A
600					(45)	c 67	105	0.6	Exp. pt. 45 Km	A
601						Z ±				E
604	145	48		93	48	c 315	196	0.7	12 Km long at first; at end oval of 6 Km diam.	E
605						315				E
608						(0			Upper part	Q
						(180			Lower part	
612						90		S	Small, or Z	A
613						Z +			Vertical component at bottom	A
614						c 225		0.2	70° drift	E
615						225			Whole train	A
619	132	105	50							E
621						N/S			10° train, not less than 80 or 100 Km; 5 strata	A
622						225				E
623						135			K 26	E
627						270			Varying velocities	E
630						270				E
636						135				E
638						c 180				E
639						(112			Upper part; K 23	E
						(292			Lower part	
642						135				S
644						Z				A
650						c 23	171	0.3	Height 88-97 Km assumed	A
651						Z			Or slowly to W	A
653						(90			Upper part	E
						(270			Lower part	
654						165				A
655						180		S		A
662						c 45		0.7		E
663						c 45				E
667	114	68	33	114	68	180		0.1	Duration longest lower end	E
670						90				A
675	93	24				c 90			Path length 280 Km	E
676	136	32±			40 +	c 225			Path length 134 Km	E
677	122	108	64	119	108	c 315	187	1	K 29	E
678	40+	11	42	(25)					Mean height train given, burst 19 Km	A
680						c 270				E
681						90+				Q
683	102	34	37						Train 0.8 Km wide; path length 147 Km	E
686	153	90								E
687						0		S		E
690	144	83	53			c 45			Path length 264 Km	E
692						225		0.3		A
693						c 90		0.4		A
694						Z +		S	Or to W, v. slow	A
695						169			K 31	A

NO.	METEOR Hb	He	V	TRAIN H_1	H_2	d	Vt	Va	REMARKS	
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
696						180			K 32	A
699	145±	84		137±	34	225	18	0.1	K.29; diffusion rate 5.8 Km/h	A
700						135				A
702	146	80	34	115	88				Path length 102 Km, train 42 Km	E
705	144	82				Z +				E
707						202			K 32	E
708						Z ±			Serpentine	A
710				(103)		c 0	400	0.4	Mid-point of train given	E
711						270				E
713						(c 23	64		K 34 Top) vel.on h=88 assumed	E
						(c 112	183		Bottom) (for mid-pt?)	
714	155	61	63	124	88				Train 12-15 Km wide, 104 Km long	E
715	145	85				90?		S	Burst at 123 Km; path 105 Km long	E
716						180		0.5		E
721						c 174		2.6		E
722				(87)		c 225	160		Height assumed 87 Km	A
724						225				E
725	142	71	74	(92)					Mid-pt. of train given; path 97 Km long	E
728	88?	18				180			Burst at 44 Km	E
729	160	69	57	91	69	45			Path length 142 Km, train 40 Km	E
731	183	59±	48						Path length 413 Km	E
732						Z?			Or to W slowly	E
733						N/S			4 strata, alternate directions	A
736						(0			Top; several strata	A
						(N/S			Remainder	
737	108	43	24			270		6.7	K 18; path length 116 Km	E
739	95	72	39						Path length 72 Km	E
742	189	100	87	127	104				0.6 Km wide; 90 Km long	E
743	268	74	33	101	74	90			0.5 Km wide; 31 Km long	E
744						158			Lower part	A
745						c 90				E
747						180		S		A
750	255	52	41	158	52	c Z			K 36, 0.1 Km wide; 119 Km long	E
751	104 ±	35±							Path 615 ± Km long	A
753						c 292	a 250	1.0	K 37; assuming h=93 Km	E
755	117	76		103	76	(c 225	193	0.3	Upper part; train 35 Km long, K 38	E
						(c 338		0.3	Lower part	
757						NE/SW			3 strata; middle prob. to N.E.	E
760	90	80	35	90	80	c 135	160		K 39; path 250 Km long	E
761						Z ±		S	Parallel strata	Q
762	138	90		121	90	(Z			Top	E
						(c 67	217	1.5	Middle part was 10 Km long	
						(Z			Bottom	
763	102	<13							Explosion point 13 Km	Q
767	140	85	57	97	90	c 315	174	1.0		E
768						Z				E
773	142 ±	74	24			c 270			Path length 72 Km	E
774						270			Near bottom; rest Z	E
775						45		2. +		E
777						c 90		S		E
778	118	24	44	74	24				Parallel strata; train length 120 Km	E
785	146	72	48	108	88	c 225	169	1.3	Vel. for 92 Km; path length 233 Km	E
786						N/S			5 strata; in S.W. direction drift ??	E
788						338				A
790						E/W			3 strata, middle prob. to W.	A
791						c 0				A
793	93	42	44						Parallel strata; path length 67 Km	E
795				48	24	270				Q
802	82	82	41							E
805	116	108								E
806	119	84		97	84					E
807						225?		S	K 40; possibly only internal motions	E
808						(225			Upper part; K 42	E
						(90			Lower part	

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
809						(0		S	Top) directions	A
						(225?		S	Bottom; slight or Z) very ??	
810	124	47							Path length 94 Km	E
812	137	87	100							E
						(c 270		0.2		
813						(c Z		0. ±		A
						(c 170		1.5	Velocity increases downward	
814						225			K 41	E
815						N/S/N			3 strata; middle prob. to S	E
817	127	86	64						Path length 77 Km	E
818	132	89	56	103	89	146	150		Path length 68 Km	E
						(90			Top; Path length 81 Km	E
821	156	16	16	70 +	16	(Z			Middle	
						(270			Bottom	
822						NE/SW		S	3 ± strata	E
824	138	79	60			Z			Path length 146 Km	E
825						292		1.0		E
829	89	18	36	(73)					Mean height ??; path length 229 Km	E
831	185 ±	10	60					S	Path length 210 Km ±	A
832	116	76	113	108	84	(c 304	129		Upper part; path length 56 Km	E
						(c 304	264		Lower part	
833				(88)		45	209		88 Km mean height assumed	E
835		(95)				270	250		Exploded at 95 Km	
									Lower part moved faster, 12x7 Km at disap.	A
838						Z			Only slight deformation	E
842	84	71	24						Length of path 72 Km	E
844						135				A
845		29							Train 19 Km long	E
846		23								E
847						23 ±				E
849						c 180				A
851						c 45		1.3		E
853						45				E
856	87 ±	47	40			315				E
						(0				E
858	111	42	32			(180			3 strata; path length 161 Km	
						(0				
860						0?			Direction uncertain	E
864		(32)				SW/NE			5 strata; burst at 32 Km	Q
865						45		S		A
871						90		1.0-		E
873	85	64	34						Path length 98 Km	E
874						Z,225Z			Motion of upper and lower part uncertain	S
875	159	78	74	95	78	338	250		V for 90 Km height	E
878						23		1.1		E
879	103	66	21			(270			V greater; path length 65 Km	A
						(90?			V less	
880						90		4.0		A
881						N/S?			At least 6; very irregular	S
						(90	118		Upper part	E
885				118	74	(135	55		Central part	
						(135	74		Lower part	
886	114	90							Path length 177 Km	E
887						158?			Very uncertain; ambiguous	A
888	108	39	32			202			V great	E
892					>100	c 225	50<	0.5		E
895	118	58	29						Knotty train; path length 144 Km	E
896						125		3	One stratum only shown; wide	S
897						90		S	Unaltered for 2 + min.	A
898	142	85	61	116	85					E
899						90?			Upper part; rest Z??	S
902						Z ±				Q
903						Z ?			Or to W; ambiguous	S

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	c/Min		
904						90?			Or Z; ambiguous	S
						(225			Top	S
906						(Z			Center	
						(45			Bottom	
915						270			Bottom; several others E/W	S
917				27±	19 +				Train 24 Km long	A
919	119	53	13						Path length 74 Km	Q
920		75		106	75	c Z			Expansion only, radial V=120 Km/h	A
924						270			Most peculiar curved path!	E
925						270		S	Very slow	Q
927						180			3 variable velocities, lower part of train only	S
937						c 135		2.1		S
940						90				Q
946	145	80	68						Path length 61 Km?	E
953	72	32							Path length 120 Km	E
954						90			3 levels, solution rather ?	Q
956						135		0.1		Q
957		110		110		270?		S	Or Z; 2 observers	E
959						0/Z/0			3 strata	S
960						90			3 strata	A
967		25				c 34			Lower condensation only	A
969						c 135				A
970						250				Q
973						23				S
979						270		S	E at first, then stationary	A
980						270		S	Top and bottom Z; center to E	E
984						350			3 levels for lower part	A
986						E/W			3 strata, vertical component also	S
987						202			Middle; 3 strata	S
990						c 112		2.2	Drift to WNW; then to NW	E
993						225		1 +		S
994						c 270	100	1.0	Height assumed	A
995						90			For strata 2 and 4 out of 5, others Z	S
996						E/W			Upper part; lower Z??	S
1001	113	35	21			20			Upper and lower parts; middle Z,	S
1002						80 ?		S	Very slow or Z	E
1003	92?	92		92?	92	c 0			End part of train drifted S; rest ??	A
1004						Z ±			Zero N-S; small E-W	A
1005						c 23				A
1006						Z				A
1007						345 ±		S	?? and small	A
1014						Z?			Or E very small	E
1015						c 146		0.4		E
1016						c 90		0.5		E
1020						Z +				S
1021						c Z				S
1022						c 292		0.7		A
1025						N/S			2 strata ?	S
1026						270			Lower part; rest ??	S
1027						180			Whole train	S
1029						c 270				A
1031						SSW/NNE			3 strata; some possibly Z	A
1033						c 180		1.0+	Slight change dir. of drift after 2 min.	A
1035						45				S
1036						315			Lower part	S
1037						180			Middle part; rest Z?	S
1041						270			Lower part	S
1042						0 ?			Debris falling only ??	A
1044						c 90		1.0	3 strata	S
1047						c 45		0.7		A
1049						c 338				A
1057						90		2. +		S

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
						(45	< 15		> 16 Km	A
1066	120	12		43	12	(Z	0		at 16 Km	
						(225	< 15		12 to 16 Km	
1068	>150	55	57			-			Path length 1000 ± Km	E
1069						E/W			4 strata	A
1072	208	115	38	187	115	-			Solution an uncertain one ??	A
1074						c 338		0.7		Q
1075						c 90		0.2		A
1078					20				Train 64 Km long; ½ Km wide ±	A
1079	103	68	55	87	68				Length of train 48 Km	E
1081	81	6	28	(81)	6	Z ±		S	Wavy motion only	A
1086		91			91	0				A
1087	119	86		(100)	(106)	15	151		Middle part; vertical component; diam. 1 Km	A
1088	(142	73		(88)	(100)	67	236		Middle part; vertical component; diam.	A
	(				100	45 ±			3.8x1.3 Km, and horizontal motion	
1089	(225	90							Burst at 91 Km; Visual data	A
	(116	90							Photographic data	
1094						c 180		0.1-		A
1095						(45			Upper part	S
						(Z			Where burst	
1102						180		S		S
1103	141	17		102	25	270 ±	280	0.2	Parts of train expanded	A
1105				((96)		296	32		Heights est. ??	E
				(	(82)	51	67		Train 24 Km long	
1106	62	10	24	50	34	Z			Train 26 Km long, path 84 Km	Q
1108	171	46		108	57	c 270	128 +		Horizontal	A
1109						20		5:		E
1110						315		1.6		E
1111						c Z				E
1112						315		1.7		E
1113						(c Z			Upper part; 5 strata indicated,	E
						(c 90		0.2	Lower part	
1114						Z			Or very slow W, 5 strata slightly indicated	E
1115						(c Z			Upper part	
						(90		0.7	Lower part, 5 strata indicated	E
1116						75		9.		E
1117						180 ±		4.5	Data ambiguous	E
1118						270		0.7	Possibly more ENE; long train, nearly all lasting full time	E
1119						c 135			Drift in upper strata twice as fast	E
1125						45			Bottom nearly Z, increasing vel. upward	E
1128						90?		S	Or Z	S
1129						270				Q
1130						270				Q
1131						270				Q
1133						112				E
1134	76	43	40	72	45	c 220		0.5	Middle, 3 strata; top +bottom Z ±	A
1135						c 353		1.0		A
1137	130	80		100	85	248	200		Assumptions made	E
1138						158		R		E
1139						10		4.		E
1141						225?			Upward ??	Q
1142						180		3.0		S
						(248	210		Height 111 Km; train length 44 Km	E
1145	151	82	34	124	90	(225	260		Height 97 Km	
						(202	240		Height 90 Km	
1146						90		1.0	Central part more rapid	E
1149						E/W			3 strata; vertical comp.	S
1151	116	44				45		16.0		E
1152	146	69								E
						(Z		0.0		S
						(0		1.0		
1154						(Z		0.0	5 strata	
						(0		1.0		
						(Z		0.0		

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	°	Km/Hr	°/Min		
						(0	121		Height 62)	A
						(180	82		47) velocities projected and	
1155						(0	30		44) minimum	
				62	31	(180	52		42)	
						(0	38		39)	
						(180	79		29	
1156	95	80			(72±)	90			Mean height; drift considerable	E
1159						180			Central part; top and bottom Z	A
1160						180		2.5		E
1161						180				E
1163						0		1.5		E
1165						c 335		2.5		E
1166						270		5.0		E
1168						260			Central part only	E
1174						(270		4.5	Direction changed	E
						(310				
1175						c 180		0.5		E
1176						(225		S		E
						(340				
1177						W/E			About 25 strata, horizontal	Q
1178						c 310		1.3		A
1180						340		0.8		E
1181						0		1.6		S
1182						c 45		0.5		E
1184	129	73	37	(93)		(228	10		Main part; rapid expansion	E
						(270			Below 90 Km	
1185						110			Middle part	E
1186						315				E
1189						c 175		1.2		A
1190						250				E
1191						250				E
1192						270				E
1194						70		R		E
1195						330		S		E
1196						(c 158			Middle part	A
						(Z			Upper and lower parts	
1197						270				E
1198						c Z				E
1199						c 270				E
1204						Z			Middle part	E
						(c 140		0.1	Upper part	E
1205						(c 140		0.3	Middle part	
						(c Z		0.0±	Lower part	
1206						c 225		0.4	Middle part only of original path	E
1207						180		5.±		Q
1209						c 0		2.5		A
1210						c Z			Or very slow	A
1211						c 90		2.0 +		S
1212						c 90		0.8		A
1214						N/S			Seen from 2 ships	A
1215						(90			Middle part	E
						(270			Lower part	
1216						112				S
1217						45±		0.2		E
1218						202				A
1219						90		0.2	4 strata; 1 and 3 prob. Z	E
1220						169			Possibly N	S
1221	119	92							Train 75 Km long; i = 147°, e = 0.74	E
1222						N/S			9 strata, vel. growing larger with dec. height	S
1224						c 225	133 +	0.8	Assuming 100 Km height	E
1226	142±	40±				67				A
1227						270				A

NO.	METEOR Hb	METEOR He	METEOR V	TRAIN H_1	TRAIN H_2	TRAIN d	TRAIN Vt	TRAIN Va	REMARKS	
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
1228						180				A
1229						195			5 strata	A
1230	129	73	39		93	(228	36		Expansion 13 Km/h	E
						(45	160		90 Km height assumed	
1231						180			5 strata; 1,3,5 to N;2,4 Z; 3 greatest vel.	S
1233	150	64		(92)					Height of middle part; length of path 100Km	E
1235						135				A
1236						270?			Lower part longest enduring	A
1237						23	161		Assuming 90 Km height	A
1239						c 0				E
1241						45		S	Uncertain data	S
1243						260			Rapid, 3 strata	S
1246						170			2 parts of train lasted longer	E
1247						168		1.5		S
1249						c 245		1.0	Assuming 90 Km height	A
1251						c 120		2.0		S
1252	96	16				90			Upper levels faster; complicated motions	A
1253						90		S	Drifted as whole?	A
1254						c 315				E
1255						90				E
1256						Z				A
1257						315		S		E
1258						SE/NW			3 strata; apex to SE	S
1259						180 ±			With a vertical component	S
1260						Z ±				A
1262	130	84	77	100	87	(90	111		At 90 Km; train expanded to 4 Km in diam.	E
						(Z	0		at 87 Km	
1263	84					315			Upper part almost stationary	S
1264	159	56	43	122	78	(210		R	122 to 96 Km level; path length 139 Km	S
						(300		R	96 to 78 Km level	
1265						225				S
1266						280		0.5 +		A
1268						50		S		A
1269						145		2.0		A
1271	112	92		(95)		270	90+		Mean height of train	E
1274				(90)		(135	67+		Upper level) height	E
						(135	148+		Lower level) assumed	
1275						135	150		90 Km assumed	E
1276						c 0		0.3		E
1277						(c 75		2.+	Or to 125°; ambiguous; top	S
						(c Z		0.	Bottom	
1278						90				S
1279						(23			Whole train for 3 min.	A
						(112			Lower half after 3 min.	
1280						Z?			Spiral; head on	S
1281						(c 23			Upper part, after division	S
						(c Z			Lower part	
1282						N/S		S	Several parallel currents?	A
1283						288		1.5		S
1284						N/S			At least 2 opposite levels	S
1285						315	160		90 Km height assumed, 3 levels	E
1286						90??	(150)	0.5-	90 Km height assumed	E
1287						225	150	1.2	90 Km height assumed	E
1288						180	105		90 Km height assumed	A
1289						135			3 levels; central part moving	E
1290						305	100		90 Km height assumed	E
1291	153	56		(129)	(62)	down	>160		Initial mean height, final mean height; mean height after 5.5 min. 113 Km	A
1292						(0	155		90 Km height	A
						(202	180		(mean?)	A
1293						Z				A
1296						(180		1.3	Upper level	A
						(180		4.0	Central level	

NO.	METEOR			TRAIN					REMARKS	
	Hb	He	V	H_1	H_2	d	Vt	Va		
	Km	Km	Km/Sec	Km	Km	o	Km/Hr	o/Min		
1297						135		S	Very small velocity, 2 levels	E
1298						(c Z			Upper part	E
						(c 60		0.3	Lower part	
1299						(c Z ±			Upper and lower part	E
						(c 67		0.2	Central part	
1300						225		0.4	All levels equal	E
1302						(Z			Upper part	S
						(0			Lower part	
1307						0			Small central part	E
1309						349				Q
1310	186	8		27	17				Path length 478 Km, train 32 Km	E
1315						90				E
1317						135			Upper central part	E
1318						(Z			Upper half	E
						(205			Lower half	
1321						135		S		E
1326						315			Central part	E
1335	77	43	53	77	43	112	204		(Z above 70, below 45 Km	E
									(motion in 70-45 Km level	

Table III

This table gives the annual and monthly distribution of the trains, along with their total numbers. The influence of the well-known cometary showers is very strongly indicated in the monthly totals.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	-	TOTAL
1801														
2														
3										1				1
4														
5										1				1
6														
7														
8														
9														
10	1													1
1811					1									1
12								2						2
13											1			1
14									1	1				2
15					1		1							2
16														
17				1										1
18		1						1		1				3
19					1						1			2
20														
1821						1			1					2
22			2			1		2	1		1			7
23								1			1			2
24														
25											2	1		3
26			1											1
27												1		1
28														
29									1					1
30														
1831											1			1
32										1				1
33											11	1		12
34							1		1					2
35											1	1		2
36								1			2			3
37								1						1
38	1		1					1			2			5
39								2						2
40	1				1		1	1						4
1841			1					1	1			1		4
42				1			1	1			1			4
43			1			1					1			3
44									2					2
45						1	1			1				3
46						2		1	1	2	3			9
47	1				1		1	2		1	2	2		10
48	1		1						1					3
49								2			4	2		8
50	1	3				1	1		1	1	1			9
1851				2	2	2					1			7
1852								1		1	1			3
53								2	1	2		1		6
54				1				2		1	1			5
55	1											2		3
56	1						2	1		1				5
57				1			1				1			3
58							1	3	1		1	1		7
59								6		2	2			10
60	1	1						2						4

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	-	TOTAL
1861			1		1		3	3		1	1			10
62	1	1		2			1		3	1				9
63							1	15	1	2	7			26
64		1			1		1	5	3		1			12
65		3					2			1	4	1		11
66	1					2	1	1		1	32			38
67						1	1	4		1	16	1		24
68						3	1	1	2		25	1		33
69					1	2		1	1		6	1		12
70		1						2	1		3	1		8
1871		2	1	2			1	1	3	1	1	2	1	15
72					1			3		1	8	1		14
73		1			1	2			2	1				7
74								1	2	2		1		6
75		1						1	1	1		1		5
76						1	2	3	2	2	1	1		12
77			1	1					2	2	2			8
78	1		1		1		2	3	2		1	1		12
79		3	1						1	2				7
80								2	2			1		5
1881										1	1	1		3
82		1			1		1	5	1	1	1			11
83	1				1	1		3		1		1		8
84					1		3		1	1		1		7
85							1				16	1		18
86								1			1	1		3
87			1	1		2		1		3				8
88						1	1	2		1	2	1		8
89		1	1					1			2			5
90	1				1	1		2						5
1891							2	4	2	3	3			14
92					1			2		1		1		5
93			1					2		1	3	2		9
94		1		1			1	4		1				8
95	1			1						1	3	1		7
96	1	2	1		1	3			2		6	1		17
97	1	2			1					3				7
98	1			1			2	1	1	2	15	1		24
99								4	1	2	2			9
1900	1	1	1	2			3		1	1		4		14
1	1			1			2	1		3	12	1		21
2	1	1					1	1	2					6
3					1	2		1		1	4			9
4					1			1		1	5	2		10
5			1			1	1	1		2	2	2		10
6	3					1	1	2			1	1		9
7		1		1			1		1	1				5
8	1	1		1			1	1		1	2	1		9
9	1	1	1	1	1	1	1	3	1	1	1	2		15
1910		1		1		1		2	2	5	2			14
1911				1	1	1	2		1	1		2		9
12			1	2		2	1	1		1				8
13	1	1				2	1		1	3				9
14	1					1		1		1		1		5
15							1	2		3				6
16	1			2		1	1	1	1	1				8
17				1	1	1	1			3				7
18		1		1	1								1	4
19				1		1				1		1		4

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	-	TOTAL
1920	1				1	2	1	1	1		1			8
21				2					1					3
22									1		3	1		5
23								1	2	1				4
24	1			1	3	2				1	1			9
25	1		1		1	1	1	1	1	2		1		10
26		1			1	2		1	3	2	2			12
27			1				3		2	4	5	2		17
28	2	1		4	1	1	2	2		7	24	1		45
29	2	1		1	1		2	4	1		2	1		15
1930		1			1	3	5	1	2	1	21	1		36
31		1	2	1	1	2	2	3	2	2	54	3		73
32	1	1	1	2	1	1	2	3	1	1	16	3		33
33	1		1		3		1	1	2	9	5	2		25
34					2	3	1	6	2	8	4	1		27
35	1	1	1		2	2	7	2	3	4	3	2		28
36				1			4	15	6	9	3	2		40
37	1	1	1		1	5		8	2	4	3	2		28
38		2	1			2	3			4	3			15
39	1			3	2		2	5	3	9	4		1	30
1940			1	2				4	1	1				9
41	1	1												2
1801) 1941)	42	44	30	47	47	69	92	190	95	157	388	77	3	1,281
Before) 1801)	2	2	6	5	4	5	5	2	6	7	4	6	1	55
TOTAL	44	46	36	52	51	74	97	192	101	164	392	83	4	1,336

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AN ANALYSIS OF VERTICAL OSCILLATIONS IN THE SOUTHERN NORTH ATLANTIC [1]

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Contribution No. 276 from the Woods Hole Oceanographic Institution

ABSTRACT

Hydrographic materials for the present analysis consisted of 28 repeated samplings of the water column, each comprising 17 observations between surface and approximately 1100 meters depth, obtained while "Atlantis" was anchored for 26 hours in 5000 meters depth at 25° 32′ N, 53° 45′ W (Station 3245). The temperature at fixed depths varied as much as 2.25° during the observation period owing to internal vertical displacements of the water layers. Smaller temperature variations (0.32°–0.36°) occurred at depths of 200–300 meters where the water column was least thermally stratified and where vertical displacements were largest (48–56 meters), whereas the larger variations characterized depths of greater thermal stratification.

Analytical transformation of the observational materials by harmonic analysis of vertical displacements of 22 selected isotherms, and subsequent statistical treatment reveals that vertical displacements are well represented by coefficients of 24 and 12 lunar hour frequencies. The effects of irregular influences are largely eliminated and characteristic space properties of the phenomenon are brought out by plotting phases and amplitudes in harmonic dials and investigating the geometric properties of the resulting point aggregates. Both diurnal and semidiurnal groups of points were characterized by marked ellipticities and the small, but significant, average vectors of vertical displacements (between surface and 1050 meters) result from combinations of larger amplitudes but of nearly opposite phases. Formulas for computation of ellipse constants, tests for significance of correlation coefficients and average vectors are given in forms suitable for numerical computation.

Statistical analysis of theoretical Internal Waves contingent in the water mass at Station 3245, computed from Fjeldstad's Internal Wave theory, reveals that significant properties of observed displacements are well represented by the theoretical mechanism. Additional geophysical significance is furnished by the phase and amplitude relations of displacement vectors, being such as to suggest a connection between Internal Wave and tidal mechanisms. Internal Wave propagation velocities in the North Atlantic, where depths exceed the average, may be approximated by dividing 221 by the wave order (1st, 2nd, etc.). Length of the first order semidiurnal Internal Wave, having a propagation velocity of 221 cm sec.$^{-1}$, is 99.05 kms, or approximately 1/100 the length of the semidiurnal tidal wave at the mean depth of the oceans.

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INTRODUCTION

INTERNAL vertical oscillations in the sea are revealed by time variations of temperature and salinity at fixed points throughout the ocean space. For adequate description of the phenomenon, numerous observations need to be transformed and reduced to patterns appropriately indicating their average state and time variability. The present analysis of approximately 500 repeated temperature measurements, has been undertaken by means of numerical methods adapted from other somewhat analogous geophysical investigations. The procedure represents a departure from customary treatments of oceanographic data; the initial descriptive discussion of observational material is followed by harmonic analyses of the vertical displacements at critical depths, and the results of the transformation then treated statistically. The final part of the paper considers comparisons of statistical properties of observed and theoretical vertical displacements and the possible relation of Internal Wave to tidal phenomena.

The basic information analyzed was obtained from 28 repeated temperature samplings [2] of the water column taken uninterruptedly at 17 subsurface levels (to 1200 meters depth) over 26 hours ($02^h\ 54^m$, January 23 to $04^h\ 45^m$, January 24, 1939, G.C.T.) while the "Atlantis" was anchored in 5000 meters depth at Station 3245 (25° 32′ N, 53° 45′ W). Due to favorable weather and absence of drift, the measurements (taken with the usual precision) were treated as having a high degree of reliability. Depths of observations changed but little between successive samplings, as evidenced by frequency distributions of temperature differences ($\Delta T°$) between protected and unprotected thermometers (Table 1) for measured wire lengths of 300, 800, and 1200 meters. The maximum computed

[2] Salinity values were determined by chemical titration of three complete samplings.

TABLE 1

Measured depth: 300 M Av. True depth: 292.6 M		Measured depth: 800 M Av. True depth: 788.6 M		Measured depth: 1200 M Av. True depth: 1179.0 M	
Temperature difference	Per cent frequency	Temperature difference	Per cent frequency	Temperature difference	Per cent frequency
2.56°–2.57°	22.2	7.80°–7.81°	4.2	10.42°–10.43°	16.0
2.58°–2.59°	22.2	7.82°–7.83°	0.0	10.44°–10.45°	16.0
2.60°–2.61°	33.4	7.84°–7.85°	25.0	10.46°–10.47°	36.0
2.62°–2.63°	22.2	7.86°–7.87°	45.8	10.48°–10.49°	28.0
		7.88°–7.89°	25.0	10.50°–10.51°	4.0

Frequency distributions of temperature differences between protected and unprotected thermometers at measured wire depths of 300, 800, and 1200 meters. Average true depths computed from temperature differences. "Atlantis" Station 3245.

variation at any depth during the entire period of observation was 9 meters and, in this case, errors in computed sampling depths may rarely be expected to exceed 3 meters and those in temperature, 0.02°.

Vertical Oscillations and Temperature Variations at Station 3245

In preparing material for analysis, the original temperature data (corrected) of each sampling were individually plotted against depth and scaled both for temperature at standard depths (see Appendix 1) and for depths of standard isotherms. Time variations of temperature at standard depths (Table 2) are considered to result chiefly from internal vertical movements of the water layers, the magnitudes of which are indicated by time variations in depths of standard isotherms (Table 3).

During the twenty-six hours at Stations 3245, temperatures at standard depths (0–1100 meters) varied from 0.32° to 2.25° (Table 2) as a result of vertical displacements of 15 to 56 meters (Table 3). The smaller temperature variations (0.32°–0.36°) occurred at depths (200–300 meters) where the water column was least stratified and where the vertical displacements were largest (48–56 meters), whereas the larger variations (1.31°–2.25°) occurred at depths (100–150 meters) characterized by the greater temperature (and density) statification, and by corresponding smaller vertical displacements (26–48 meters). In the moderately strongly stratified mid-depths, temperature variation of 0.57° to 0.66°, between 500 and 800 meters, corresponded with vertical displacements of 28 to 41 meters, while still deeper, with diminishing temperature (and density) stratification, temperature variations diminished; at 1100 meters (greatest depth sampled) a variation of 0.24° corresponded to a 47 meter vertical displacement.

General relationships between diurnal temperature ranges at fixed depths (Table 2) and vertical displacements of the water column (Table 3) to vertical distributions of temperature and density (σ_t) and to vertical variations of density ($\Delta\sigma_t/\Delta Z$) are brought out by Fig. 1. Computations of temperature and vertical displacement ranges are affected by randomness of the observations; if measurements had extended over several days a more satisfactory analysis would have been possible (such, for instance, as that carried out on 13 days of continuous observations at Station 3091.[3] Nevertheless, it is brought out that the apparent damping of vertical displacements by increased stratification is insufficient to offset increased temperature varia-

TABLE 2

Depth	Average temperature	Maximum temperature	Minimum temperature	Temperature range
0	23.99°	24.55°	23.65°	0.60°
100	21.96°	22.47°	21.16°	1.31°
150	19.29°	21.08°	18.83°	2.25°
200	18.12°	18.30°	17.98°	0.32°
300	17.47°	17.71°	17.35°	0.36°
400	16.52°	16.77°	16.32°	0.45°
500	14.95°	15.31°	14.74°	0.57°
600	13.14°	13.46°	12.83°	0.63°
700	11.04°	11.30°	10.67°	0.63°
800	9.08°	9.30°	8.64°	0.66°
900	7.71°	7.88°	7.56°	0.32°
1000	6.47°	6.79°	6.29°	0.50°
1100	5.73°	5.87°	5.63°	0.24°

Resumé of temperature variations at standard depths for "Atlantis" Station 3245 from $02^h\ 54^m$, January 23 to $04^h\ 45^m$, January 24, 1939 (G.C.T.). Scaled values.

[3] Seiwell, H. R. "Daily Temperature Variations in the Western North Atlantic." *Journal du Conseil*, XIV, No. 3, pp. 357–369, 1939.

TABLE 3

Isotherm	Maximum depth	Minimum depth	Range (meters)
23.00°	82.5	42.2	40.3
22.00°	110.0	77.9	32.1
21.00°	151.8	103.3	48.5
20.00°	161.9	124.5	37.4
19.00°	170.0	144.1	25.9
18.00°	254.0	198.0	56.0
17.50°	325.5	278.0	47.5
17.00°	376.5	338.0	38.5
16.50°	423.0	387.0	36.0
16.00°	458.2	422.0	36.2
15.00°	519.8	484.0	35.8
14.00°	572.0	536.2	35.8
13.00°	620.0	591.0	29.0
12.00°	663.8	636.2	27.6
11.00°	715.5	683.0	32.5
10.00°	770.0	731.0	39.0
9.00°	820.0	778.5	41.5
8.50°	852.0	810.0	42.0
8.00°	883.0	867.8	15.2
7.50°	934.0	906.0	28.0
7.00°	979.5	943.0	36.5
6.00°	1086.0	1039.5	46.5

Resumé of time variations in depth of standard isotherms for "Atlantis" Station 3245 from $02^h\ 45^m$, January 23 to $04^h\ 45^m$, January 24, 1939 (G.C.T.). Values scaled for indicated isotherms.

tions at the fixed depths concerned. For instance, the most strongly stratified layer of water, between 100 and 150 meters depth (average vertical variation of σ_t: $\Delta\sigma_t/\Delta Z = 114.97 \times 10^{-4}$ units of σ_t per meter; average vertical variation of temperature: $\Delta T°/\Delta Z = 4.98 \times 10^{-2}$ degrees per meter), was characterized by an average diurnal vertical displacement of 38.5 meters and a corresponding average temperature change of 1.92°. In the more homogeneous water immediately below, between 200 and 300 meters, where average density stratification ($\Delta\sigma_t/\Delta Z = 9.97 \times 10^{-4}$) was reduced to 8.67 per cent of the above and the vertical variation of temperature ($\Delta T°/\Delta Z = 6.7 \times 10^{-3}$ degrees per meter) to 13.5 per cent, the average diurnal vertical displacement of 51.0 meters produced an average temperature variation of only 0.33°. Still deeper, in the thermocline, where, between 500 and 800 meters, density stratification increased ($\Delta\sigma_t/\Delta Z = 17.71 \times 10^{-4}$), 1.78 times and temperature stratification ($\Delta T°/\Delta Z = 19.4 \times 10^{-3}$) 2.89 times the above, the average vertical displacements were reduced to 34.0 meters or 67 per cent of the above and the accompanying average temperature variation increased 1.89 times, or to 0.627°. In the deepest water layers sampled (between 900 and 1100 meters), the average density stratification ($\Delta\sigma_t/\Delta Z = 8.42 \times 10^{-4}$) decreased to 47.5 per cent, and the temperature stratification ($\Delta T°/\Delta Z = 9.73 \times 10^{-3}$) to 5[illegible] per cent of its former value, but the average vertical displacement increased 1.15 times to 39. meters, producing an average diurnal temperature variation of only 0.390°. These interrelationships are similar to those in other North Atlantic [4] areas and it may be inferred that the more homogeneous layers of the ocean basins (to depths of approximately 1200–1400 meters) are charterized by relatively larger vertical displacements and smaller diurnal temperature variations.

Harmonic Analysis of Isotherm-Depth Variations

Results of harmonic analysis of depth variations of selected isotherms for 24 and 12 lunar hour components are tabulated in Table 4 as values of the coefficients, C and α, thus:

$$H = C_0 + C_1 \cos \frac{2\pi}{24}(t - \alpha_1) + C_2 \cos \frac{2\pi}{12}(t - \alpha_2).$$

Phases and amplitudes were determined by least squares,[5] the former (in lunar hours) having been adjusted to refer from the time of the previous upper transit of the moon at the Greenwich meridian which occurred at $13^h\ 32.3^m$ (G.C.T.) on January 22, 1939. Thus analyses were made of the observational series, beginning 14 lunar hours ($03^h\ 57^m$, January 23, 1939, G.C.T.) after the time of the moon's upper transit at the Greenwich meridian on January 22 and ending 14 lunar hours ($04^h\ 40^m$, January 24, 1939) after its upper transit the following day, January 23 ($14^h\ 14^m$; G.C.T.). Consequently the phase angles recorded in Table 4 have been increased by 14 lunar hours, this procedure being preferable to referring the phase to some arbitrary time, even though the coefficients do not necessarily

[4] Seiwell, H. R. "Time Variability of Hydrographic Elements Determining the Dynamic Situation in the Western North Atlantic." *Proceedings of American Philosophical Society*, LXXXII, No. 3, pp. 369–394, 1940.

[5] Seiwell, H. R. "Short Period Vertical Oscillations in the Western Basin of the North Atlantic." Papers in *Physical Oceanography and Meteorology*, V, No. 2, 44 pp., 1937.

apply outside of the original observation period. The results of harmonic analyses of vertical displacements for 6 isotherms are illustrated by Fig. 2.

In general, vertical variations of phase angles, amplitudes and ratios of amplitudes (C_{24}/C_{12}) are identified with the internal structure of the water column in that vertical transitions closely coincide with temperature and density stratification (Fig. 1, Table 4). In the upper strongly stratified part of the water column, approximately between 50 and 150 meters, the phase of both waves change rapidly with depth; amplitudes of both waves were relatively low with the semidiurnal wave dominating, (average C_{24}/C_{12} = 0.648). Somewhat deeper, in the more homogeneous water between 150 and 450 meters, both 24 and 12 hourly waves maintained more nearly uniform phase angles and the amplitudes of both waves attained maximum values, with the 12 hour amplitude again dominating (average C_{24}/C_{12} = 0.525). In still deeper water of increased stability, as between 550 and 1050 meters (Fig. 1), vertical variation of phase angles again increased and amplitudes were, on the whole, diminished, but the lunar diurnal wave generally dominated.

TABLE 4

Isotherm	C_0	C_{24}	α_{24}	C_{12}	α_{12}	C_{24}/C_{12}
23.0°	62.52	5.39	23.39ʰ	5.56	7.08ʰ	0.97
22.0°	99.28	4.56	22.56ʰ	5.09	7.71ʰ	0.901
21.0°	118.74	0.84	7.50ʰ	6.72	8.45ʰ	0.125
20.0°	135.11	0.94	11.20ʰ	2.04	8.96ʰ	0.461
19.0°	157.58	2.48	12.07ʰ	2.53	1.01ʰ	0.980
18.0°	216.46	13.33	15.73ʰ	11.01	3.36ʰ	1.211
17.5°	295.80	5.41	15.86°	10.27	2.66ʰ	0.527
17.0°	356.79	2.85	17.89ʰ	11.21	3.15ʰ	0.254
16.5°	400.76	2.43	15.23ʰ	8.52	3.75ʰ	0.285
16.0°	434.22	4.42	13.17ʰ	15.34	3.58ʰ	0.288
15.0°	497.08	4.01	13.53ʰ	12.82	2.65ʰ	0.313
14.0°	555.24	1.57	16.00ʰ	11.82	2.43ʰ	0.133
13.0°	607.66	1.03	2.12ʰ	5.78	3.72ʰ	0.178
12.0°	653.18	3.87	17.65ʰ	2.76	4.29ʰ	1.40
11.0°	702.23	4.69	17.60ʰ	5.12	5.48ʰ	0.916
10.0°	755.36	8.28	7.00ʰ	4.22	4.85ʰ	1.962
9.0°	805.28	6.88	11.46ʰ	5.02	3.97ʰ	1.371
8.5°	835.32	7.82	14.53ʰ	3.33	4.92ʰ	2.348
8.0°	875.05	2.79	21.44ʰ	1.21	2.58ʰ	2.306
7.5°	918.95	6.54	0.76ʰ	1.21	3.64ʰ	5.405
7.0°	956.95	4.24	21.03ʰ	9.36	11.16ʰ	0.453
6.0°	1057.45	11.87	22.85ʰ	8.24	11.53ʰ	1.44

Lunar diurnal and lunar semidiurnal coefficients of observed vertical displacements of isotherms at "Atlantis" station 3245.

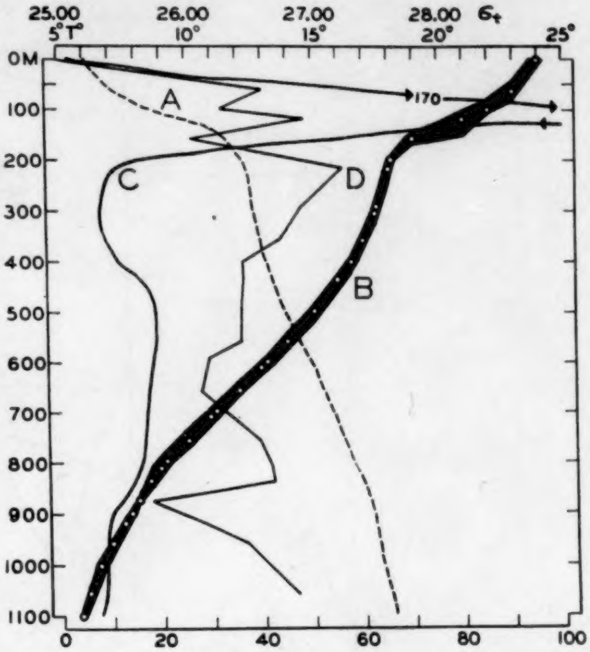

FIG. 1. "Atlantis" Station 3245. 02ʰ 54ᵐ, January 23 to 04ʰ 45ᵐ, January 24, 1939 (G.C.T.). A = average vertical distribution of density (σ_t); B = average vertical distribution of temperature, variation at fixed depths indicated by width of ribbon; C = average vertical rate of change of density per meter, $\Delta\sigma_t/\Delta Z$; D = vertical displacements of water column during observation period (referred to bottom scale, meters).

The Apparent Dominance of 24 and 12 Lunar Hour Periods in Vertical Oscillations of the Water Column

(a) *Examination of Residues after Extraction of 24 and 12 Lunar Hour Waves*

As a possible means of estimating the dominance of 24 and 12 lunar hour periods in vertical oscillations of the water layers (Table 4), the residues, after extraction of these waves from original observed vertical displacements of isotherms, were combined into a single frequency distribution (Table 5) and tested for normality. This procedure is used since the normal curve, having been mathematically deduced as the distribution resulting from combination of an infinite number of small random errors, has a fundamental status, and a quantity, such as the above, distributed according to this law may be the result of uncontrolled chance causes. On the other hand, if the distribution of residues

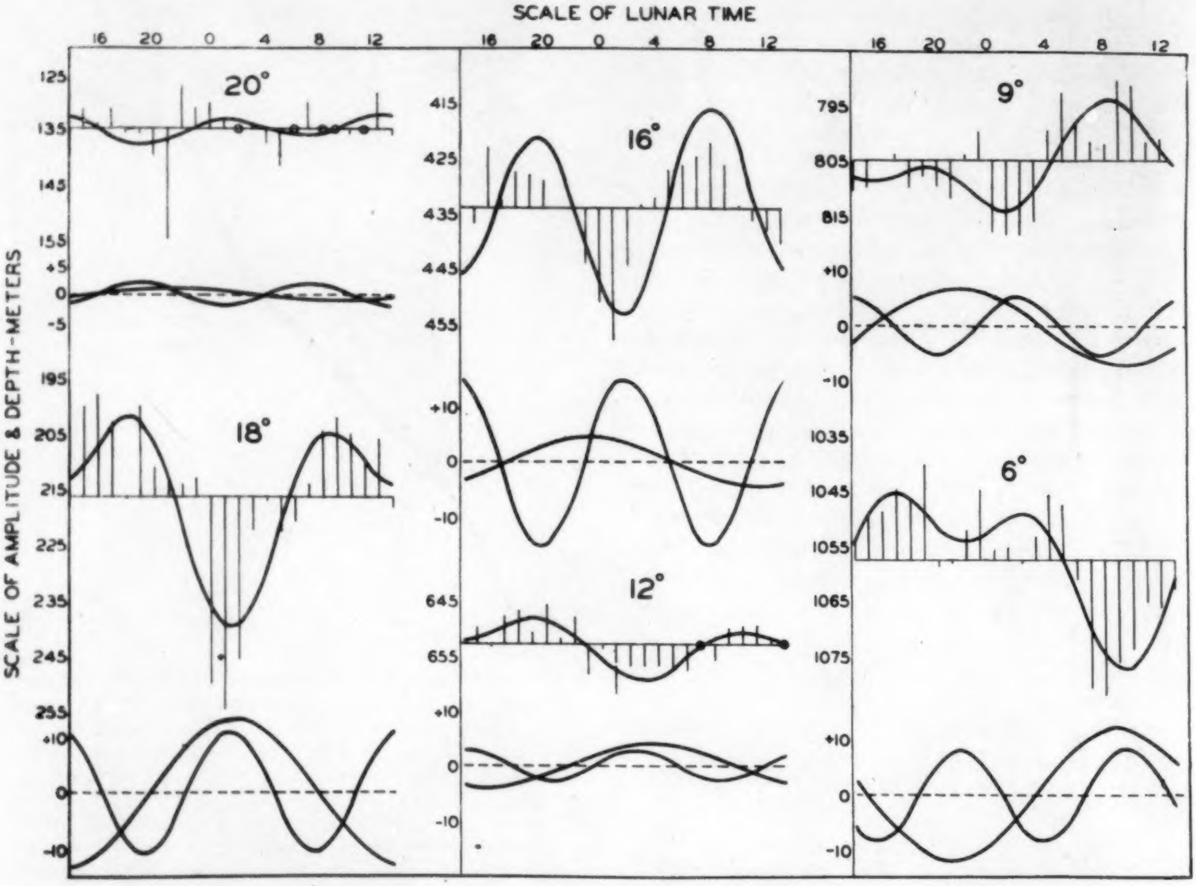

FIG. 2. Harmonic analysis of vertical displacements of 20°, 18°, 16°, 12°, 9° and 6° isotherms, Station 3245. Observed vertical displacements shown as departures from mean values to which are fitted curves based on sums of computed lunar diurnal and lunar semidiurnal sine waves—also shown separately. Time scale in lunar hours, 0^h representing moon's upper transit at Greenwich meridian on January 23, 1939 (14^h 14^m, G.C.T.).

should be non-normal, it may be inferred that they are not all the result of chance, and quite possibly contain an additional geophysical controlled oscillation. Naturally, this use of the normal distribution is to some extent open to question and like any application of probability theory needs to be considered with a "grain of salt," and the result may be chiefly empirical. However, in the absence of more definite information, it seems reasonable that its use as a test for randomness in the data under consideration should give basic information on the nature of the controlling geophysical phenomenon.

The frequency distribution of residues resulting after subtraction of combined 24 and 12 lunar hour waves from the original vertical displacements of 22 isotherms is given in Table 5. The first four corrected movements about the mean (using Bernoulli class marks) are:

$$\mu_1 = 0$$
$$\mu_2 = 1.93182$$
$$\mu_3 = 0.20417$$
$$\mu_4 = 13.54395,$$

and the following statistics for testing normality of the distribution are:

$$\sigma = \sqrt{\mu_2} = 1.389899$$

$$\beta_1 = \frac{\mu_3^2}{\mu_2^3} = 0.005782$$

$$\gamma = \sqrt{\beta_1} = 0.07603$$

$$\beta_2 = \frac{\mu_4}{\mu_2^2} = 3.629209$$

$$\omega_n' = 0.81622$$

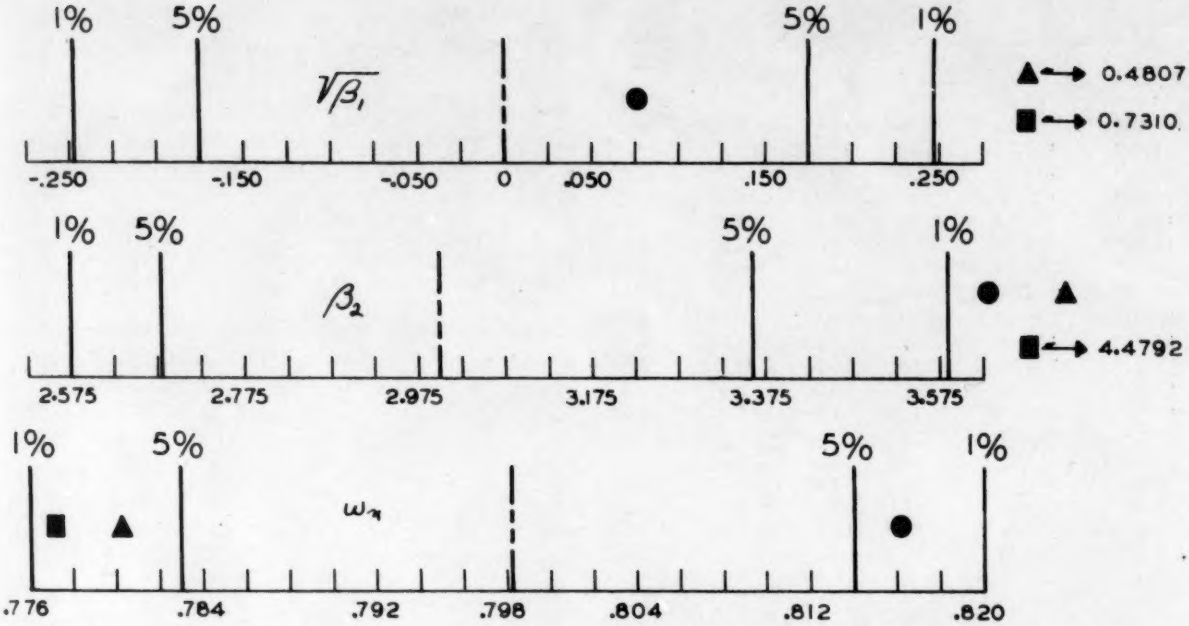

FIG. 3. 5 per cent and 1 per cent probability limits for a random sample of 528 individuals drawn from a normal population. Values for frequency distribution of residues after subtraction of 24 and 12 lunar hour waves = ●; for original frequency distribution of departures from mean = ■; and for frequency distribution of residues after subtraction of 12 pendulum hour and 12 lunar hour combination = ▲.

(ω_n' being the ratio of the mean to the standard deviation of the distribution). In testing for departure from normality, two separate tests, one regarding skewness and the other kurtosis, are generally used. To detect lack of symmetry (skewness), the $\sqrt{\beta_1}$ appears to be a suitable criterion,[6] and tables of 5 per cent and 1 per cent levels [7] are generally believed to be sufficiently accurate for ordinary purposes. For tests of platykurtic or leptokurtic properties, Pearson suggests the ω_n' test of R. C. Geary [8] as being preferable to the β_2 test, since the distribution of the latter, particularly for small samples, is not well known.

Results of all three tests for normality ($\sqrt{\beta_1}$, β_2, ω_n') applied to the foregoing frequency distribution are given by Fig. 3. The value of $\sqrt{\beta_1} = 0.07603$ for $n' = 528$ is well above the 5 per cent probability level; $\beta_2 = 3.629$ falls a little below the 1 per cent level whereas the value $\omega_n' = 0.81622$ for $n' = 528$, according to Geary's (1935) table F, falls about midway between the 5 per cent (0.814) and 1 per cent (0.820) probability levels.

Hence, it appears that the distribution of residues is random, or sufficiently so to suggest that for practical purposes (in the absence of more pertinent information) the vertical oscillation mechanism of the water column at the station investigated may be considered as being

TABLE 5

Class interval (meters)	Frequency
−20.0 to −16.1	2
−16.0 to −12.1	7
−12.0 to − 8.1	30
− 8.0 to − 4.1	79
− 4.0 to − 0.1	147
0.0 to 3.9	142
4.0 to 7.9	89
8.0 to 11.9	21
12.0 to 15.9	8
16.0 to 19.9	2
20.0 to 23.9	1
	528

[6] Pearson, E. S. "A Comparison of β_2 and Mr. Geary's Criteria." *Biometrica*, XXVII, Memoir XII, Section II, pp. 333–352, 1935.

[7] Tables for Statisticians and Biometricians. Part II, Table XXXVII bis, page 224. Biometric Laboratory, University of London.

[8] Geary, R. C. "Introduction of the Ratio ω_n' and its Distribution." *Biometrica*, XXVII, Memoir XII, Section I, pp. 310–332, 1935.

TABLE 6

Isotherm	C_0	C_1	α_1	C_2	α_2
23.00°	63.88	6.44	11.73	5.25	9.45
22.00°	99.53	6.50	11.96	5.33	10.19
21.00°	117.77	2.53	12.83	3.32	11.38
20.00°	134.48	2.00	10.92	2.01	11.52
19.00°	157.23	3.02	9.12	0.97	3.42
18.00°	215.13	14.13	5.20	9.68	5.34
17.50°	295.73	4.36	7.76	14.91	5.51
17.00°	358.07	3.31	13.36	12.87	4.58
16.50°	402.42	2.79	3.32	11.67	4.41
16.00°	436.19	4.39	1.19	9.90	4.66
15.00°	498.48	2.09	5.50	10.27	5.19
14.00°	555.09	4.78	12.10	8.16	5.70
13.00°	607.28	5.43	12.87	5.47	5.56
12.00°	654.68	6.17	7.69	1.91	6.42
11.00°	703.42	7.53	8.16	4.41	7.85
10.00°	755.69	5.36	20.82	5.01	6.83
9.00°	805.60	2.43	27.45	5.17	6.03
8.50°	836.34	5.61	5.20	2.94	7.22
8.00°	875.76	4.62	12.03	1.34	3.76
7.50°	917.83	7.73	14.79	1.57	5.01
7.00°	957.15	2.39	14.03	9.71	1.03
6.00°	1056.29	10.38	12.76	9.32	1.40

Results of harmonic analysis of observed vertical displacements of isotherms at "Atlantis" Station 3245 for periods of 12 pendulum hours and of 12 lunar hours.

dominated by frequencies of 12 and 24 lunar hours.

Application of the Chi squared test for goodness of fit to the normal frequency curve best fitting the data:

$$F = \frac{528}{1.3899}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{X-0.4981}{1.3899}\right)^2}$$

(where X is the Bernouilli class mark: 0, 1, 2, 3, $\cdots$ n) gives satisfactory results. Grouping frequencies less than 7, at the tails of the curve, the value of the Chi squared function is:

$$\chi^2 = \frac{(F_1 - f_1)^2}{F_1} + \frac{(F_2 - f_2)^2}{F_2} + \cdots + \frac{(F_n - f_n)^2}{F_n} = 6.34497$$

(where F is the theoretical and f the observed frequency). Computation was based on 8 groups (after clubbing frequencies at the tails of the curve); in fitting the Gaussian curve, 3 constants are fixed (total, mean and standard deviation) so that 5 (n) degrees of freedom remain. Hence, entering Elderton's tables[9] at $n' = 6$ ($n' = n + 1$), the value of the Pearson probability is:

$$P = 0.2767,$$

from which may be concluded that in 27.7 times out of 100 we should get in random sampling a fit as bad, or worse, if the real distribution were Gaussian.

[9] Tables for Statisticians and Biometricians. Part I, Table XII.

(b) *Examination of Original Frequency Distribution*

The foregoing frequency distribution of residues is now compared with the distribution composed of observed vertical displacements of identical isotherms, expressed as departures from mean values before the extraction of the 24 and 12 lunar hour waves. The size of the sample is, of course, the same; the first four corrected movements about the mean (using Bernoulli class marks):

$$\mu_1 = 0$$
$$\mu_2 = 4.49913$$
$$\mu_3 = 6.97801$$
$$\mu_4 = 90.66770$$

were used to compute the following statistics:

$$\sigma = \sqrt{\mu_2} = 2.1211$$
$$\beta_1 = \frac{\mu_3^2}{\mu_2^3} = 0.53467$$
$$\gamma = \sqrt{\beta_1} = 0.73100$$
$$\beta_2 = \frac{\mu_4}{\mu_2^2} = 4.47916$$
$$\omega_n' = 0.7773.$$

Values for $\sqrt{\beta_1}$, β_2 and ω_n' entered in the chart (Fig. 3) of their probability limits for $n' = 528$ definitely indicate a non-normal distribution; in particular the controlled oscillations in the distribution causes an extreme skewness to the left ($\sqrt{\beta_1} = 0.53467$).

(c) *Examination of Residues after Extraction of a 12 Pendulum Hour Wave and a 12 Lunar Hour Wave*

The foregoing application of probability theory to the analysis of vertical oscillations of the water column permits the inference that (on the basis of existing evidence) the observed oscillations are well described by lunar diurnal and lunar semidiurnal periods, plus residual motions resulting from random causes. Because of the brief observational series, as well as theoretical restrictions on the analytical methods, conclusions of more theoretical or more practical value are not at present permissible. However, since it has been suggested that vertical displacements may exist as free inertial motions having periods of 12 pendulum hours, it is desirable to reexamine the original data from this point of view and to make a comparison with the results of the foregoing analysis.

Thus, at the latitude of Station 3245, (φ = 25° 32′ N) the length of one half pendulum day, or 12 pendulum hours $= \frac{12}{\sin \varphi} = 27.84$ sidereal hours, and the period of an inertia wave (12 pendulum hours) will be only 3.14 sidereal hours in excess of that of a lunar diurnal wave (24.70 sidereal hours) and could not be decisively separated by harmonic analysis of so short an observational series as that under consideration. Values of the coefficients:

$$H = C_0 + C_1 \cos \frac{2\pi}{27.84} (t - \alpha_1)$$

for a possible 12 pendulum hour component in vertical displacements of isotherms are tabulated in Table 6; phase angles (in sidereal hours) are adjusted to refer from 0^h Greenwich (January 23, 1939), although the analyses were actually carried out on an observational series which began 3 hours later ($03^h\ 00^m$, G.C.T., January 23, 1939).

After extraction of a 12 pendulum hour wave from the original observations of vertical displacements of isotherms, examination of the residues indicated the presence of an additional wave having a period length of approximately 12 lunar hours (such as would be expected because of small differences in period lengths of the inertia and lunar diurnal components at this latitude). Thus, a second harmonic analysis was carried out on the 22 residues, the results of which are tabulated as coefficients of a second lunar semidiurnal component:

$$C_2 \cos \frac{2\pi}{12.353} (t - \alpha_2)$$

in Table 6; phase angles also given in sidereal hours, refer to 0^h Greenwich (January 23, 1939) as before. Amplitudes both of the 12 pendulum hour and 12 lunar hour waves of this second computation differ by small amounts only from those previously computed for the lunar diurnal and lunar semidiurnal waves (Table 4), and as a means of estimating which of the two combinations of components best represent the observed vertical displacements, the final residues, after extraction of the latter combination, were analyzed as before.

TABLE 7

Class interval (meters)	Frequency
−20 to −16.1	1
−16 to −12.1	3
−12 to − 8.1	32
− 8 to − 4.1	104
− 4 to − 0.1	155
0 to 3.9	129
4 to 7.9	76
8 to 11.9	19
12 to 15.9	4
16 to 19.9	3
20 to 23.9	1
24 to 27.9	1
	528

The frequency distribution of residues resulting after subtraction of the combination of a 12 pendulum hour wave and a 12 lunar hour wave from the vertical displacements of the 22 isotherms as given in Table 7 has the same class intervals as that for the frequency distribution of residues in Table 5. The first four moments about the mean are:

$$\mu_1 = 0$$
$$\mu_2 = 2.02727$$
$$\mu_3 = 1.38742$$
$$\mu_4 = 15.29430,$$

and the following statistics are computed for the distribution:

$$\sigma = 1.4238$$
$$\beta_1 = 0.23104$$
$$\gamma = 0.48066$$
$$\beta_2 = 3.7214$$
$$\omega_n' = 0.7803.$$

Values of $\sqrt{\beta_1}$, β_2 and ω_n' entered in the chart of probability limits for a sample of 528 individuals (Fig. 3) clearly show that the distribution under consideration is not normal. The statistical characteristics of dispersion, skewness and kurtosis characterizing the original frequency distribution of observed displacements of isotherms, while significantly reduced by extraction of inertia and lunar semidiurnal components, still indicate significant departures from normality. In particular, the strong asymmetry of the present distribution is decisive in deciding its non-normality. Hence, in the present case, vertical oscillations of water layers are far better represented by the combination of lunar diurnal and lunar semidiurnal waves than by a combina-

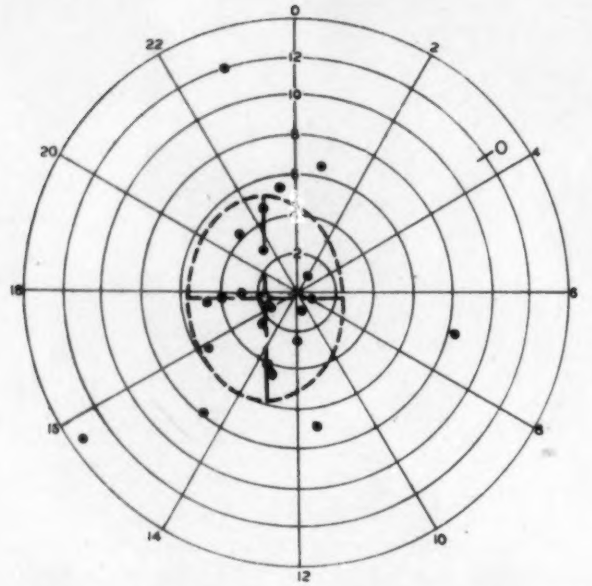

FIG. 4. Harmonic dial for 24 lunar hourly sine wave in diurnal variations of vertical displacements of 22 isotherms at "Atlantis" Station 3245 (25° 32′N, 53° 45′W), and 50 per cent probable ellipse. Scale refers from moon's upper transit at Greenwich ($13^h\ 32^m$, January 22, 1939), and inner 0 indicates moon's upper transit at meridian of Station 3245 ($17^h\ 14^m$, January 22, 1939. G.C.T.). Each dot marks an isotherm, length of vector from center gives amplitude (in meters) and its direction, the phase in lunar hours.

tion of a 12 pendulum hour and a lunar semidiurnal wave, thus justifying the use of the former combination for future discussion. For the present, the physical significance of this inference remains problematical.

SPACE VARIABILITY OF THE LUNAR DIURNAL AND LUNAR SEMIDIURNAL COMPONENTS

Since the lunar diurnal and lunar semidiurnal components of vertical oscillations of the water column are specified completely by amplitudes and the times of maxima (phase angles), the sine and cosine function of each frequency have been combined into sine waves with amplitudes, C, and phases, α. Thus:

$$X \cos a + Y \sin a = C \cos (a - \alpha)$$

with:

$$X = C \sin \alpha$$
$$Y = C \cos \alpha$$
$$C^2 = X^2 + Y^2$$
$$\tan \alpha = \frac{X}{Y} \cdot$$

The relations for each frequency are conveniently illustrated by plotting in polar coördinate (the "harmonic dial" of Bartels [10]); each point then has the coördinates C and α, the lengths of the vector being C and its azimuth, α. Thus N sets of harmonic coffiecients may be represented on each dial as a group of N points (Figs. 4, 5, 6 and 7) and the space variability of the vertical oscillations so represented may be transferred into the geometric properties of the group. In the plane coördinate system each point has the rectangular coördinates X_ν, Y_ν ($\nu = 1, 2, 3, \cdots n$), and the coördinates of the center C (X_0, Y_0) are:

$$X_0 = \Sigma X_\nu / N$$
$$Y_0 = \Sigma Y_\nu / N.$$

We also have:

$$\sigma_x^2 = \frac{\Sigma(X_\nu - X_0)}{N}$$
$$\sigma_y^2 = \frac{\Sigma(Y_\nu - Y_0)}{N}$$
$$r\sigma_x\sigma_y = \frac{\Sigma(X_\nu - X_0)(Y_\nu - Y_0)}{N},$$

where r is the usual correlation coefficient between X_ν and Y_ν. The general Gaussian frequency distribution (normal correlation surface) which has the equation:

$$df = \frac{N}{2\pi\sigma_x\sigma_y\sqrt{1 - r^2}} e^{-\frac{1}{2(1-r^2)}\left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} - 2r\frac{XY}{\sigma_x\sigma_y}\right)} dxdy$$

(where X and Y are variants, measured as deviations from their means X_0 and Y_0) and which best fits the cloud of points (judged by least squares) is to be computed.

The formulae used in the computation are given in a form suitable for numerical computation.[11] The value of:

$$\frac{1}{1 - r^2}\left(\frac{X^2}{\sigma_x^2} + \frac{Y^2}{\sigma_y^2} - \frac{2rXY}{\sigma_x\sigma_y}\right) = \text{constant}$$

and the lines of equal frequency are ellipses with center at C. The major axis of the ellipse is inclined toward the X axis by θ where:

$$\tan 2\theta = \frac{2r\sigma_x\sigma_y}{\sigma_x^2 - \sigma_y^2}$$

[10] Bartels, J. "Statistical Methods for Research on Diurnal Variations." *Terrestrial Magnetism and Atmospheric Electricity*, XXXVII, No. 3, pp. 291–302, 1932.
[11] Reference footnote 10.

and lies between 0° and 90° when $r > 0$, between 90° and 180° when $r < 0$; for $r = 0$, $\theta = 0$ when $\sigma_x > \sigma_y$, and 90° when $\sigma_x < \sigma_y$. When $\sigma_x = \sigma_y$, the ellipses degenerate into circles.

The average square distance (M) of each point from the center, C, has been termed by Bartels the "two dimensional standard deviation," thus:

$$M^2 = \frac{(X_\nu - X_0)^2 + (Y_\nu - Y_0)^2}{N}$$

and is useful in measuring dispersion of the group of points.

In the case of a perfect Gaussian distribution, the total probability that a point falls outside the ellipse is:

$$e^{-\frac{1}{2(1-r^2)}\left(\frac{X^2}{\sigma_x^2}+\frac{Y^2}{\sigma_y^2}+\frac{2rXY}{\sigma_x\sigma_y}\right)}.$$

The probable ellipse surrounding $N/2$ points both inside and outside is:

$$e^{-\frac{1}{2(1-r^2)}\left(\frac{X^2}{\sigma_x^2}+\frac{Y^2}{\sigma_y^2}+\frac{2rXY}{\sigma_x\sigma_y}\right)} = \frac{1}{2},$$

its semi-major (P_1) and semi-minor (P_2) axes being:

$$P_1, P_2 = 0.83256\sqrt{(\sigma_x^2 + \sigma_y^2) \pm \sqrt{(\sigma_x^2 - \sigma_y^2) + 4r^2\sigma_x^2\sigma_y^2}}.$$

Also, in general:

$$\sqrt{P_1^2 + P_2^2} = 1.1774M.$$

Since the formulae give constants of a Gaussian distribution which best fit the group of points without presupposing that the group itself is Gaussian, values may always be computed. As a partial test of normality the number of points inside and outside the probable ellipse should be nearly equal.

Harmonic dials in which phases and amplitudes of lunar diurnal and lunar semidiurnal components of vertical oscillations of 22 isotherms (Table 4) are represented as single points and, the 50 per cent probability ellipses fitting each group of points, are illustrated by figures 4 and 5. The ellipses represent both distributions fairly

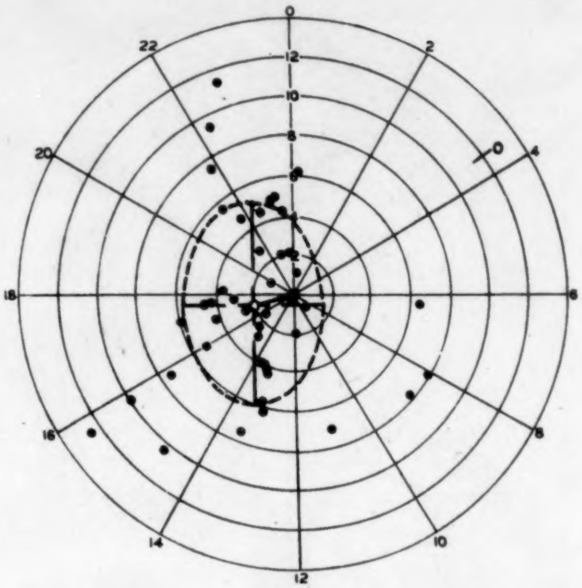

FIG. 6. Harmonic dial for 24 lunar hourly sine wave in diurnal variations of vertical displacements at forty-three 25 meter intervals (over a depth of 1050 meters) based on scaled phase and amplitude relations (see text) at "Atlantis" Station 3245. The 50 per cent probable ellipse and average vector are shown. Scale refers from moon's upper transit at Greenwich ($13^h 32^m$, January 22, 1939) and inner 0 indicates moon's upper transit at meridian of Station 3245 ($17^h 14^m$, January 22, 1939. G.C.T.). Each dot marks a depth, length of vector from center gives amplitude (in meters) and its direction, the phase in lunar hours.

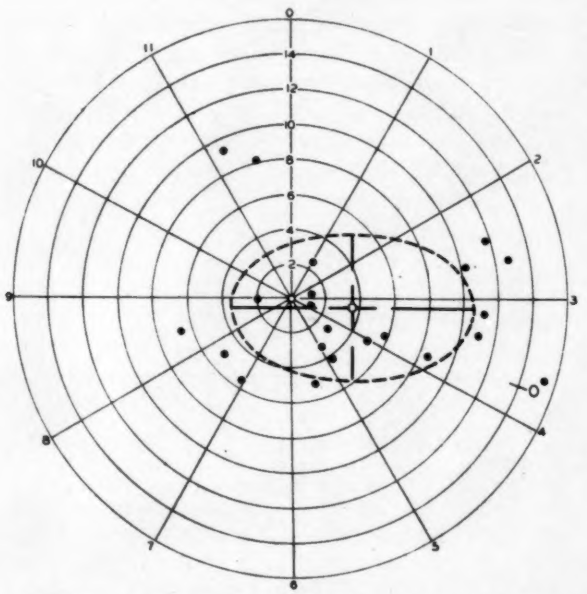

FIG. 5. Harmonic dial for 12 lunar hourly sine wave in diurnal variations of vertical displacements of 22 isotherms at "Atlantis" Station 3245 (25° 32′N, 53° 45′W), and 50 per cent probable ellipse. Scale refers from moon's upper transit at Greenwich ($13^h 32^m$, January 22, 1939), and inner 0 indicates moon's upper transit at meridian of Station 3245 ($17^h 14^m$, January 22, 1939. G.C.T.). Each dot marks an isotherm, length of vector from center gives amplitude (in meters) and its direction, the phase in lunar hours.

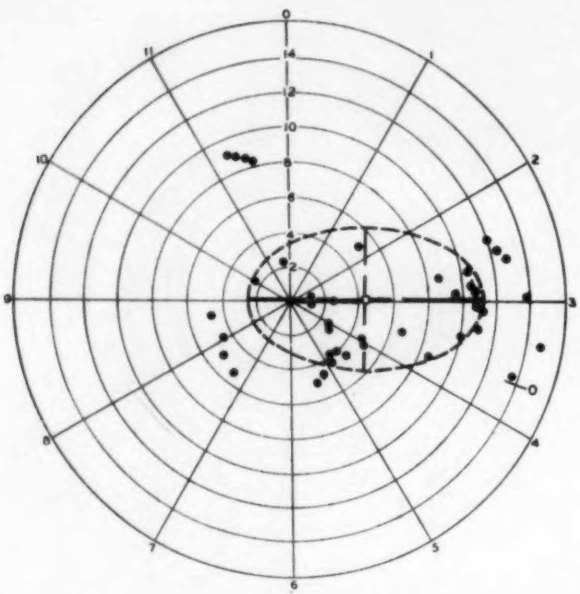

FIG. 7. Harmonic dial for 12 lunar hourly sine wave in diurnal variations of vertical displacements at forty-three 25 meter intervals (over a depth of 1050 meters) based on scaled phase and amplitude relations (see text) at "Atlantis" Station 3245. The 50 per cent probable ellipse and average vector are shown. Scale refers from moon's upper transit at Greenwich ($13^h 32^m$, January 22, 1939) and inner 0 indicates moon's upper transit at meridian of Station 3245 ($17^h 14^m$, January 22, 1939. G.C.T.). Each dot marks a depth, length of vector from center gives amplitude (in meters) and its direction, the phase in lunar hours.

well, especially for the 12 hourly components where 10 of the 22 points lie inside.

Comparison of points on the diagrams do not suggest strong interrelationships of the properties of the two waves. Thus, for points lying inside the two ellipses, only those characterizing 6 isotherms were common to both and for those falling outside, only 3 were common to both, indicating that isotherms with large or small amplitudes in one wave do not necessarily have corresponding large or small amplitudes in the other. Thus, of the 6 isotherms with 12 lunar hour amplitudes in excess of 10 meters (18.0°, 17.5°, 17.0°, 16.0°, 15.0°, 14.0°) only one (18°) had a comparable 24 hour amplitude (13.33 meters); the others ranged from 1.57 to 5.41 meters. Likewise, the 6° isotherm with a relatively large 24 hour amplitude of 11.87 meters had a corresponding 12 hour amplitude of 8.24 meters only. Isotherms in the principal thermocline having smallest 24 hour amplitudes of 1.57 and 1.03 meters (14.0° and 13.0° isotherms) had corresponding large 12 hour amplitudes of 11.82 and 5.78 meters, and isotherms of the smaller 12 hour amplitudes of 1.21 meters (7.5° and 8.0° isotherms) showed 24 hour amplitudes of 6.54 and 2.79 meters respectively.

Statistical constants for the lunar diurnal and lunar semidiurnal coefficients, as tabulated in Table 8, illustrate distinctions in geometric properties. Those tabulations under the heading "isotherms" were computed from harmonic constants derived from vertical oscillations of 22 isotherms (Table 4), whereas those under the heading "standard depths" are based on scaled phase and amplitude relations for forty-three 25 meter intervals, over a depth of 1050 meters. With regard to the use of scaled values, it was found that on comparison with a sufficient number of direct harmonic analyses at the depths concerned, satisfactory verification of the scaled coefficients was obtained and, as brought out by Table 8, geometric properties for the lunar diurnal and semidiurnal frequencies, whether based on coefficients derived directly from isothermal values or from scaled values for equal depth intervals, are without essential difference. Harmonic dials of interpolated values are given by Figs. 6 and 7 and, with the exception of the average properties, computations based on either set of point aggregates for a particular frequency may equally well characterize the water column to a depth of 1050 meters, this depth being the approximate lower limit of most significant stratification (Fig. 1).

TABLE 8

	Isotherms		Standard depths	
	12^h	24^h	12^h	24^h
σ_x	3.6024	4.3882	3.6103	4.3707
σ_y	5.9819	3.3949	5.7393	3.0349
r	−0.1043	0.16240	−0.18967	0.05292
M	6.983	5.548	6.7805	5.3211
P_1	7.0643	5.2591	6.8339	5.1528
P_2	4.2053	3.8749	4.1272	3.5638
P_1/P_2	1.6799	1.3572	1.6558	1.4459
θ	95° 35′ (90°)	16° 01′ (0°)	100° 47′ (90°)	4° 02′ (0°)
Av. Vector	——	——	4.38	2.21

Statistical constants computed for 50 per cent correlation ellipses from harmonic coefficients of lunar diurnal and lunar semidiurnal waves. Data under heading "isotherms" based on harmonic coefficients as computed for vertical oscillations of isotherms (in Table 4); data under heading "standard depths," based on harmonic coefficients for every 25 meters (0–1050 meters), scaled from those computed for isotherms.

For the semidiurnal coefficients, σ_y is significantly greater than σ_x, whereas for the diurnal, σ_x is greater than σ_y. Consequently, a marked ellipticity, most pronounced for the semidiurnal cloud, is an essential feature in both distributions. The directions of the major axes of the ellipses differ by 90°. Actual computation gives $\theta = 95°\ 35'$ and $\theta = 100°\ 47'$ for the semidiurnal coefficients and $\theta = 16°\ 01'$ and $\theta = 4°\ 2'$ for the diurnal, but, since rotation of the ellipse depends directly on the magnitude of the correlation coefficient, r (Table 8), which does not in either case differ significantly from zero (as shown below), the value of θ is taken to be 0° or 90° depending on whether σ_x or σ_y is the greater.

Testing the significance of r on the basis of the null hypothesis (assuming the correlation coefficient for an infinitely large supply of paired values following the normal law to be zero), the probability of any value of r arising because of random sampling errors, is with adequate accuracy given by the relative deviate k of r in the normal distribution of zero mean, referred to values of the normal probability integral.[12]

In a sample size of $N = 20$, or above, the standard deviation (σ_r) of the true distribution of r distributed normally about 0 is:

$$\sigma_r = \frac{1}{\sqrt{N-1}}$$

and the relative deviate k of r in the normal distribution of zero mean is:

$$k = \frac{r - 0}{\dfrac{1}{\sqrt{N-1}}} = r\sqrt{N-1}.$$

Thus for the 12 lunar hour wave:
r computed from harmonic coefficients of isotherms $= -0.10432$

$$k = 0.10432\sqrt{22-1} = 0.478,$$

and the probability of the deviate being exceeded is:

$$P = 0.631;$$

also, r computed from interpolated coefficients $= -0.18967$,

$$k = 0.18967\sqrt{43-1} = 1.229,$$

and the probability of the deviate being exceeded is:

$$P = 0.219.$$

For the 24 lunar hour wave:
r computed from harmonic coefficients of isotherms $= 0.1624$,

$$k = 0.1624\sqrt{22-1} = 0.744,$$

and the probability of the deviate being exceeded is:

$$P = 0.459;$$

also r computed from interpolated coefficients $= 0.0529$,

$$k = 0.0529\sqrt{43-1} = 0.343,$$

and the probability of the deviate being exceeded is:

$$P = 0.734.$$

Hence in all cases the correlation coefficients are of no apparent statistical significance, and the angle θ is not significantly different from 0° or 90°, depending on whether σ_x or σ_y is greater. The amount by which θ varies without consequence because of chance variation of r is estimated on the basis of a 5 per cent level being the demarcation point of significant deviations, in which case the limit of significant values of k will be just under 2 and correlation coefficients up to twice the standard deviations, σ_r, will be considered arising by chance.

For the case where $N = 22$, the standard deviation of r is:

$$\sigma_r = \frac{1}{\sqrt{N-1}} = 0.2182,$$

and when r is less than $2\sigma_r = \mp 0.4364$, θ will not differ significantly from 0° to 90°. In the computation of θ from the 12 lunar hour coefficients (isothermal values):

$$\frac{\sigma_x \sigma_y}{\sigma_x^2 - \sigma_y^2} = -0.94489,$$

which substituted together with the value of $2\sigma_r = -0.4364$ for r, in the equation:

$$\tan 2\theta = 2r\frac{\sigma_x \sigma_y}{\sigma_x^2 - \sigma_y^2} = 0.8730$$

[12] When k is the relative deviate of the measure normally distributed, and P the probability of the k magnitude being exceeded solely through errors of random sampling, then:

$$P = \frac{\text{area of tail beyond } k}{\text{area of curve segment having same sign as } k}.$$

Values of P are rapidly obtained from a table of normal curve functions.

gives a value of 20° 35′ as the latitude of chance variations in θ. Similarly for the 24 lunar hour coefficients (isothermal values):

$$\frac{\sigma_x \sigma_y}{\sigma_x^2 - \sigma_y^2} = 1.9271,$$

which substituted with the value of $2\sigma_r = 0.43649$ in the equation for θ gives 29° 40′ as the latitude of chance variation in θ.

In the Bartels'[13] approach to time series analysis, amplitude and phase of the average sine wave for each harmonic dial point aggregate are represented by an average vector, the end point of which is the mass center (Figs. 6 and 7). Of the several possibilities for testing reality of average vectors, one chosen by Bartels is to compare the observations (vectors plotted in harmonic dials) with the so-called random walk;[14] it being supposed that points plotted in the dials were chosen at random from a normally distributed aggregate. The expectancy, m, for the average amplitude, defined as the square root of the average square distance of the points is:

$$m = \sqrt{\frac{l_1^2 + l_2^2 + \cdots l_n^2}{n}} \Big/ \sqrt{n},$$

and the probability that the average vector, C, (vectorial sum divided by n) exceeds its expectancy in the ratio $k = C/m$ is:

$$P_{(k)} = e^{-k^2}.$$

$P_{(k)}$ is shown by Bartels to be exactly the probability that, under random walk conditions, an amplitude greater than $C = km$ should be found.

Thus, for the lunar diurnal coefficients, the average amplitude (C) of vertical displacements of the water column between 0 and 1050 meters, computed as the vectorial sum of 43 vectors, is 2.2058 meters. Under random conditions, the expectancy for the average amplitude of the 43 individual waves is:

$$m = \sqrt{\frac{1427.2735}{43}} \Big/ \sqrt{43} = 0.87859,$$

$$k = \frac{C}{m} = \frac{2.2058}{0.87859} = 2.5106$$

and

$$P_{(k)} = e^{-(2.5106)^2} = 0.00183.$$

Hence the probability for chance occurrence is once in about 500 trials, a value generally considered as not too small to make a definite claim that the observations do not correspond to the random walk with which they have been compared and an assumption of reality is warranted.

For the lunar semidiurnal coefficients, the average amplitude (C) of vertical displacements between 0 and 1050 meters, computed as before, is 4.383 meters. Under random conditions, the expectance for the average amplitude of the 43 individual waves is:

$$m = \sqrt{\frac{2802.8508}{43}} \Big/ \sqrt{43} = 1.23121,$$

$$k = \frac{C}{m} = \frac{4.382}{1.2312} = 3.5594$$

and

$$P_{(k)} = e^{-(3.5594)^2} = 0.000000315.$$

The probability for chance occurrence is so small that, as in the previous case, reality of the semidiurnal average vector may be assumed (Figs. 6 and 7). Significance of the average vectors in relating Internal Wave and tidal phenomena is discussed later.

The Theoretical Internal Waves

Additional consequences of the preceding statistical analysis are revealed by consideration of the theoretical Internal Waves contingent in the water masses under consideration. Thus, in a sea where density varies continuously with depth, possible wave motion is disclosed by investigation of the second order differential equation:[15]

$$\frac{d^2W}{dZ^2} + \lambda^2 g \varphi W = 0$$

with boundary conditions:

$W = 0, \quad Z = 0, \quad$ at the bottom
$W = 0, \quad Z = h, \quad$ at the surface.

W represents the elevation of a water particle from its equilibrium position, φ is taken as $d\sigma_t/dZ$ (vertical variation of density), and $\lambda^2 g$, an unknown parameter, depends on density distribution. The integration is carried out numerically, and an infinite number of solutions, corresponding to an infinite number of Internal Waves are possible; values of W are relative and

[13] Bartels, J. "Random Fluctuations, Persistence, etc." *Terrestrial Magnetism and Atmospheric Electricity*, XL, No. 1, pp. 1–60, 1935.

[14] Originally formulated by Karl Pearson: "The Problem of the Random Walk." *Nature*, LXXII, p. 294, 1905.

[15] Fjeldstad, Jonas Ekman. "Interne Wellen." *Geofysiske Publikasjoner*, X, No. 6, 35, pp., 1933.

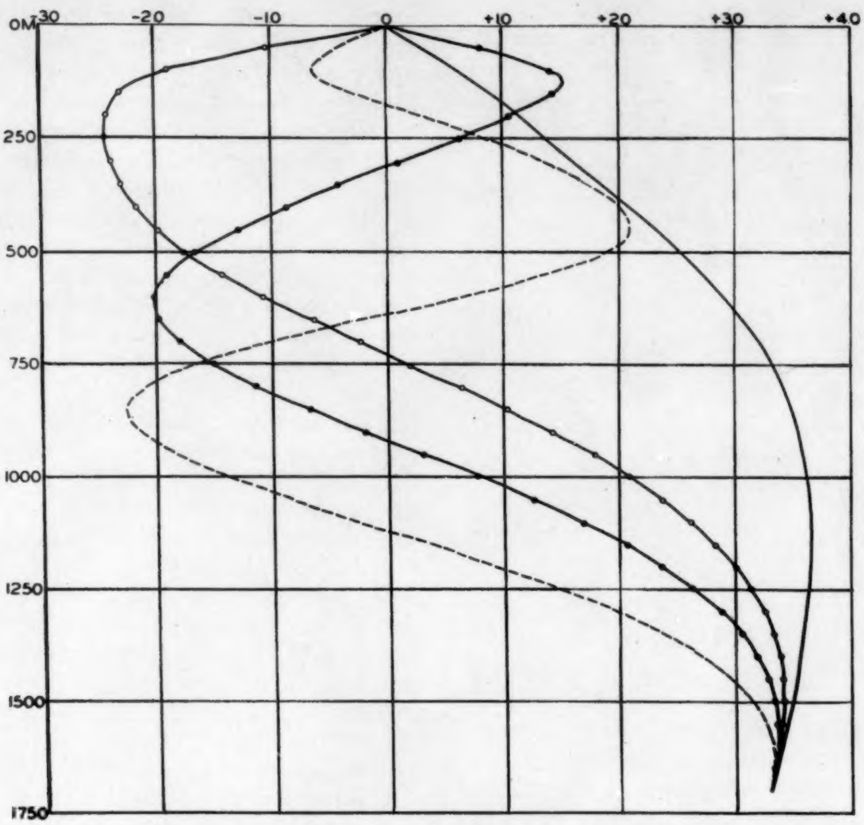

FIG. 8. Vertical distributions of first four Internal Waves; relative values, W, at "Atlantis" Station 3245.

distributions for the first four orders, between surface and 1700 meters are illustrated by Fig. 8. The first order wave is characterized by vertical displacements of the same phase with one maximum, the second order wave by two maxima of opposite phase, the third order wave by three maxima of opposite phase, and the fourth order wave by four maxima of opposite phase (Table 9). Horizontal velocity of the Internal Wave current is zero at the maximum of vertical displacement.

Absolute theoretical displacements of significant isotherms were determined by fitting W values (by least squares) to the diurnal and semidiurnal coefficients of sine waves as computed directly from observed vertical displacements of 22 isotherms (Table 4). The theoretical lunar diurnal and semidiurnal coefficients, so obtained for vertical displacements of 20 isotherms at Station 3245 (identical with isotherms tabulated in Table 4 with the 7.0° and 6.0° omitted) and the fifty per cent probability ellipses fitting the scatterings, are entered in harmonic dials (Fig 9); statistical constants for these new distributions are tabulated in Table 10.

Before proceeding to examination of the new statistical results, the probability that computed values of the correlation coefficients, r, arise because of random sampling errors, and corrections for θ in the theoretical results are considered. Thus, for a sample, $N = 20$, the standard deviation, σ_r, of the true distribution of r distributed normally about 0 is:

$$\sigma_r = \frac{1}{\sqrt{N-1}} = \frac{1}{\sqrt{19}} = 0.2294.$$

For the theoretical 12 lunar hour point aggregate, the relative deviate k of r in the normal distribution of the zero mean is:

$$k = \frac{r - 0}{\dfrac{1}{\sqrt{N-1}}} = 3.609,$$

TABLE 9

Depth	1st order wave	2nd order wave	3rd order wave	4th order wave
0	0.00	0.00	0.00	0.00
100				−0.6405
120			1.5421	
170				0.0000
230		−2.4237		
310			0.0000	
430				2.1088
610			−2.0188	
640				0.0000
730		0.0000		
850				−2.2508
920			0.0000	
1120				0.0000
1130	3.6610			
1490		3.4183		
1570			3.3729	
1630				3.3370

Maxima and minima of relative displacement amplitudes, W, first four orders of Internal Waves, Sation 3245.

the probability of the deviate being exceeded is:

$$P = 0.0003,$$

and the correlation coefficient is of apparent statistical significance. Chance variations in r of two times its standard deviation, σ_r, will produce variations in the computed value of θ. Thus letting:

$$r = 0.828 - 2\sigma_r$$

$$\tan 2\theta = \frac{2r\sigma_x\sigma_y}{\sigma_x^2 - \sigma_y^2} = -0.8673$$

$$\theta = 69° 33',$$

equivalent to a possible increase of 11 degrees above the computed value (Table 10), but nearly 20 degrees less than θ characterizing the 12 hourly group of observed values (Table 8).

For the theoretical 24 lunar hour point aggregate the relative deviate k of r in the normal distribution of the zero mean is:

$$k = \frac{r - 0}{\frac{1}{\sqrt{N-1}}} = 1.674,$$

and the probability of the deviate being exceeded is:

$$P = 0.0949.$$

Since the 5 per cent level is generally selected as the demarcation point of significant deviations, reality of the correlation coefficient is, in this case, doubtful, and apparently the result of chance variations. Hence, the angle θ is zero (σ_x greater than σ_y), identical with θ for the observed 24 hour point aggregate.

Regardless of irregular interference of various influences, the statistical distinctions between theoretical 12 and 24 hour point aggregates are similar to those existing between the two groups of coefficients computed directly from observations (Tables 8 and 10). For the theoretical semidiurnal group, σ_y is greater than σ_x and for the 24 hour, σ_x exceeds σ_y; likewise the absolute scattering of points, M, the major axis, P_1, the ellipticity, P_1/P_2, and the average vector of the semidiurnal group exceed the diurnal. The major axis of the theoretical diurnal ellipse is (like the observed) in a direction clockwise from the major axis of the semidiurnal ellipse (Figs. 4, 5, and 9); actual computation gives the direction as 1.96 lunar hours for the former and 13.06 lunar hours for the latter. However, since the correlation coefficient, r, for the diurnal point aggregate is not significantly different from 0, the major axis direction is taken as 12 hours, whereas for the semidiurnal group, chance variations of two times the standard deviation of r permits a major axis direction of 2.32 hours.

Comparison of theoretical and observed 12 hour coefficients shows, as a striking feature, an increased ellipticity of the former from $P_1/P_2 = 1.68$ to $P_1/P_2 = 3.61$ (major axis increased 53 per cent and minor axis diminished by 29 per cent), illustrating the theoretical semidiurnal wave motions of the water column to be of more nearly opposite phase with a corresponding smaller average amplitude (Tables 8 and 10). The absolute scattering of points, M, increased from 6.983 to 9.534 for the theoretical aggregate, and relative to the average amplitude the scatter-

TABLE 10

	Lunar semidiurnal	Lunar diurnal
σ_x	5.259	1.626
σ_y	7.953	0.908
r	0.828	0.348
M	9.534	1.860
P_1	10.8233	1.9732
P_2	3.0022	0.9583
P_1/P_2	3.6051	2.059
θ	58° 36′	15° 57′
	(69° 33′)	(0°)
Av. Vector	2.604	1.38

Statistical constants computed from theoretical harmonic coefficients for vertical displacements of 20 isotherms (see text).

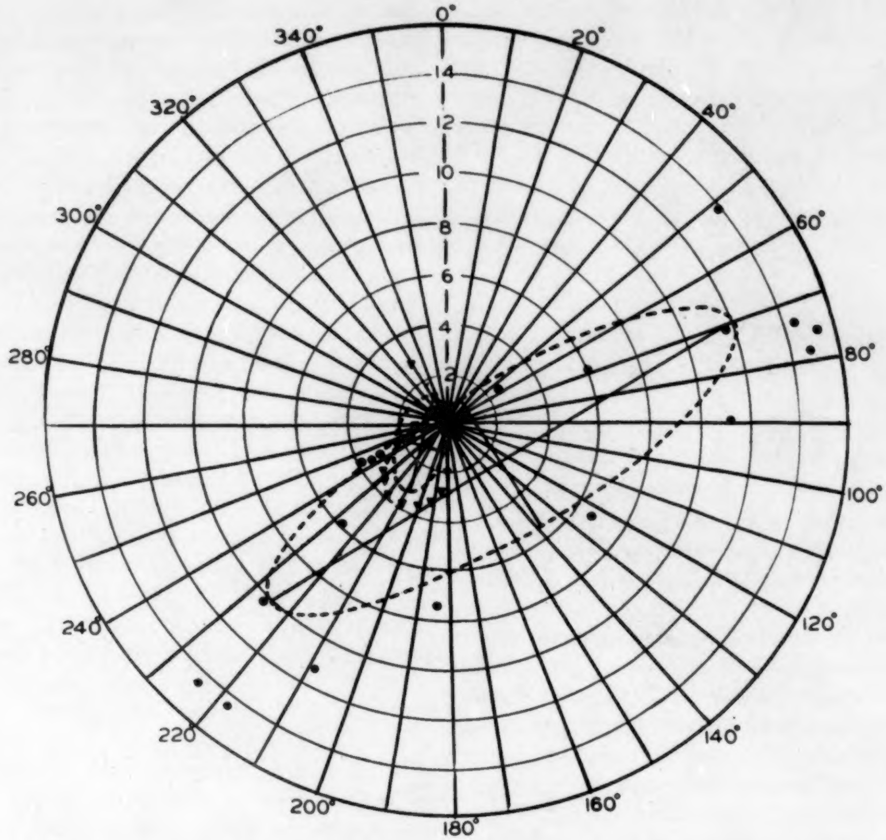

FIG. 9. Harmonic dials of theoretical semidiurnal, ⊙, and diurnal, △, vertical displacements of 20 isotherms computed from Fjeldstad's theory (see text). Scale references identical with those for dials of observed displacements (Figs. 4 to 7). Orientation of 50 per cent probability ellipses according to computed values of θ.

ing was 0.273 for the theoretical as compared with 0.514 for the observed point aggregate. The direction of the major axis of the theoretical ellipse with a possible value of 2.32 hours is not greatly different from the value of 3 hours computed for the major axis direction of the ellipse characterizing the observed coefficients.

Positions of the axes of the ellipses characterizing both groups of semidiurnal coefficients indicate greater variability among phase angles than amplitudes (Figs. 5 and 9). Thus, the major axis' end points for the theoretical 12 hour coefficients corresponded to amplitudes of 10.1 and 12.1 meters and to phase angles of 70° and 225°; the minor axis' end points corresponded to 1.1 and 5.5 meters and 30° and 138°. Observed amplitudes are somewhat more variable than the theoretical; the major axis' end points corresponded to amplitudes of 3.6 and 10.7 meters and to phase angles of 93° and 261°, and the minor axis' end points to 5.1 and 5.9 meters and 44° and 143°. Greater variability of observed amplitudes is to be expected since theoretical amplitudes, although in general larger, are more balanced by nearly opposite phase angles.

Comparison of the two groups of 24 hour coefficients (Tables 8 and 10) shows increased ellipticity for the theoretical point aggregate from $P_1/P_2 = 1.36$ to $P_1/P_2 = 2.06$, thus, indicating that theoretical diurnal wave motions were also balanced by more nearly opposite phases. The absolute scattering of the points, M, diminished from 5.55 for the observed to 1.86 for the theoretical group. Rotation of both ellipses appears to be identical, the directions of both major axes being taken as 12 hours.

Positions of the 24 hour ellipse axes indicate greater space variability of phase angles than of amplitudes (Figs. 4 and 9). The major axis' end points of the theoretical ellipse corresponded to amplitudes of 1.2 and 3.2 meters and to phase angles of 210° and 334°, minor axis' end points corresponded to 1.2 and 2.2 meters and to 190° and 255°. Some increased variability characterizes the observed coefficients, the major axis' end points corresponding to amplitudes of 5.2 and 5.8 meters and to phase angles of 196° and 342°, and minor axis' end points to 2.4 and 5.6 meters and to 98° and 267°.

Geophysical Properties of the Vertical Oscillations Brought out by Analysis

The previous procedure of representing a set of ordinates over the interval $t = 0$ to $t = T$ as a sum of two sine waves is purely mathematical and does not involve the physical nature of the Internal Wave phenomenon described by the ordinates. In particular, the fact that the sum of the two sine waves is periodic, repeating values after intervals which are multiples of T, does not imply a similar property of this phenomenon outside the range of observation. Questions of the physical meaning of the extracted sine waves and of their average properties and space variabilities for the most part will remain unanswered until additional critical information, in forms suitable for comparison with analogous geophysical phenomena, is available. The technique used in analysis of the vertical oscillation time series was developed chiefly by J. Bartels [16] for research on variability of diurnal variations in certain geophysical time series. However, unlike the long series analyzed by Bartels, the present interpretation of results of harmonic analyses of vertical displacements deals with space rather than with time variability. The statistical perspectives brought out by the analysis are basically important in characterizing distinctions in space distributions of lunar diurnal and semidiurnal vertical oscillations of the water column (for the observation period at Station 3245) and in indicating a connection between vertical oscillation and tidal mechanisms. The information in Table 8 is conducive to the comparison of Internal Wave effects throughout the ocean space.

Dissimilarities in the 24 and 12 lunar hour waves are clearly discernible. The harmonic coefficients of observed displacements, plotted in the two harmonic dials, reveal that identical points did not have corresponding large or small amplitudes, and with the exception of a marked ellipticity, characteristic to both, geometric properties of the two point aggregates differed significantly (Figs. 4, 5, 6, 7, Table 8). The 12 hourly coefficients possessed most marked ellipticity, largest average amplitudes and greatest amounts of scattering. However, the pronounced ellipticity of both point aggregates indicates the small average amplitudes are produced by combinations of larger amplitudes but of nearly opposite phases. The phase of the average vector for the semidiurnal coefficients of observed displacements (between 0 and 1050 meters) was 2.97^h referred to Greenwich zero, or approximately 43 minutes before the upper culmination of the moon at the meridian of Station 3245, whereas that for the diurnal cloud was approximately 14 lunar hours later, 17.20 hours after Greenwich zero or $13^h\ 31^m$ after the local upper culmination. Further differences in space characteristics of the two waves are a variation in directions of major axes of the probability ellipses (03^h for the semidiurnal, 12^h for the diurnal) and by major axis direction of the semidiurnal cloud nearly coinciding with the phase of its average vector, whereas for the diurnal cloud the directions differed by more than 5 hours.

The properties of the average vectors suggest a connection between Internal Wave and tidal mechanisms. As illustrated by Table 8, average phases and amplitudes of the semidiurnal and diurnal coefficients (at 25 meter intervals) between surface and 1050 meters were:

Semidiurnal: 4.38 meters, 2.97^h (89°)
Diurnal: 2.21 meters, 17.17^h (257° 30′).

And the phase difference (diurnal minus semidiurnal) of 2.2 lunar hours is not greatly different from the approximate 3.5 hour difference in phases of the semidiurnal and diurnal tides [17] at the geographical position of Station 3245 as shown by cotidal charts of R. Sterneck [18]

[16] Reference footnote 13. See also: Hafstad, L. R. "On the Bartels Technique for Time-Series Analysis, and its Relation to the Analysis of Variance." *Journal of the American Statistical Association*, **35**, 347–361, 1940.

[17] Phase of semidiurnal tide scaled to be approximately 11.5 lunar hours and that of diurnal tide approximately 15 lunar hours.

[18] Diurnal and semidiurnal cotidal charts of R. Sterneck reprinted by Albert Defant: "Die Gezeiten und Inneren Gezeitenwellen des Atlantischen Ozeans." *Deutsche Atlantische Expedition, "Meteor," 1925–1927*, VII, Part 1, 1932, Fig. 197 (Page 283) and Fig. 203 (Page 292). See also R. Sterneck: "Die Gezeiten im Atlantischen Ozean," *Annalen der Hydrographie und Maritimen Meteorology,*

(Figs. 10 and 11). The relative importance of equilibrium heights of principal tidal components of the lunar tide [19] as given by theoretical coefficients are:

M_2	N_2	S_2	K_1	O_1	P_1
0.4543	0.0880	0.2120	0.2655	0.1886	0.0880

And the equilibrium ratio,

$$\frac{M_2 + N_2 + S_2}{K_1 + O_1 + P_1} = 1.39,$$

is not greatly different from the ratio,

$$\frac{\text{semidiurnal}}{\text{diurnal}} = 1.982,$$

for average amplitudes of internal vertical displacements of the water column between 0 and 1050 meters at Station 3245.

Since tidal observations have been entirely restricted to the comparatively shallow portions of the sea actual conditions in the deep waters are unknown. The subject of ocean tides has not been accurately or completely treated and as a consequence, endeavors to link up tidal and Internal Wave mechanisms are made with caution. However, the intimation that the two mechanisms are associated appears to be further augmented by consideration of the ratio of amplitudes of the average semidiurnal and diurnal vectors (Table 8) in relation to available tidal information from the geographical locality of Station 3245.

As far as is known the tides in the ocean do not conform to the equilibrium theory,[20] and in the Atlantic Ocean, due to the smallness of the diurnal wave, the semidiurnal tide generally dominates. In low latitudes the ratio of $\frac{\text{semidiurnal}}{\text{diurnal}}$ tidal amplitudes frequently is considerably in excess of 2; along the eastern American coast it increases southward, for instance, from 2.92 at Wilmington, N. C., to 6.41 at Savannah, Ga., a location six and one half degrees north of Station 3245. Tidal information nearest to Station 3245 comes from the Caribbean region, where because the various basins respond in different degrees to the tide producing forces, the semidiurnal tides are very small and in places the total tide is largely diurnal. The ratios of semidiurnal to diurnal tide amplitudes of 2.98 to 0.25, computed from tidal harmonic constants (Table 11) for exposed West Indian Islands, include the average Internal Wave displacement ratio of 1.98 at Station 3245.

In the water column harmonic coefficients for vertical displacements of 22 isotherms reveal a trend which does not detract from the intimation of an association with tidal phenomena. In 19 cases occurrence of semidiurnal and diurnal maxima were within three hours of each other and in 14 of the 22 cases semidiurnal amplitudes dominated. As previously brought out, phase and amplitude changes are identified with the water column structure; greater vertical variations occurring in the more stratified parts. The dominance of the semidiurnal oscillation

48, No. 10, pp. 396–398, 1920, and "Die Gezeiten des Ozeans. 11. Sitzungsberichte der Akademie der Wissenschaften" in *Wien*, *Mathem.-Naturw. Klasse*, **130**, 363–371, 1921.

[19] Schureman, Paul. A manual of the Harmonic Analysis and Prediction of Tides. *Special Publication* No. 98, U. S. Coast and Geodetic Survey, 416 pp., 1924.

[20] The equilibrium tidal theory requires a level ocean surface, a situation which cannot exist in nature because too great a length of time is required for the free wave to cross and recross.

[21] Harris, Rollin A. Manual of Tides. Part IV A. Report of 1900, U. S. Coast and Geodetic Survey, Appendix No. 7, pp. 535–699, 1901.

[22] Reference footnote 19.

TABLE 11

Place	Latitude North	Longitude West	M_2	S_2	N_2	K_1	O_1	P_1	$\frac{\text{Semidiurnal}}{\text{Diurnal}}$
Savannah, Tybee Is. Lgt.	32° 02′	80° 51′	3.22	0.59	0.68	0.34	0.24	0.12	6.414
Charleston, S. C.	32° 46′	79° 56′	2.48	0.43	0.56	0.34	0.25	0.11	4.957
Wilmington, N. C.	34° 14′	77° 57′	1.15	0.10	0.18	0.25	0.16	0.08	2.918
Port au Prince, Haiti	18° 34′	72° 22′	0.487	0.125	0.107	0.227	0.132	(0.082)	1.630
San Juan, Porto Rico	18° 29′	66° 07′	0.487	0.074	0.113	0.270	0.238	0.089	1.129
Culebra Island	18° 18′	65° 17′	0.293	0.043	0.048	0.250	0.186	(0.083)	0.740
St. Thomas Island	18° 20′	64° 56′	0.124	0.031		0.295	0.243	0.078	0.252
St. Lucia Island	14° 01′	61° 00′	0.246	0.127		(0.069)	0.056		2.980

Tidal Harmonic constants for selected stations nearest Station 3245, first three from Harris,[21] last five from Schureman.[22]

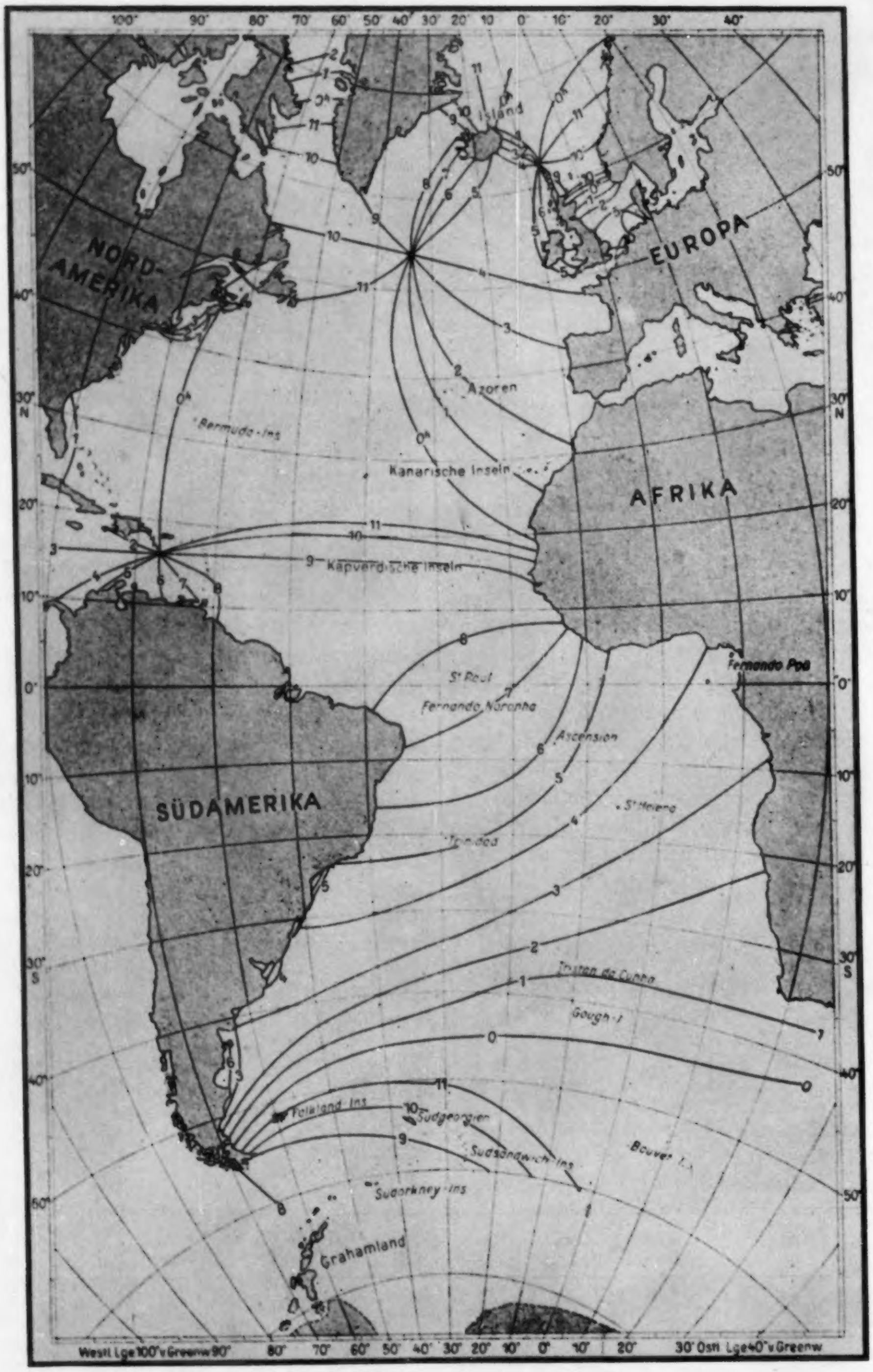

FIG. 10. Cotidal lines of semidiurnal tide in the Atlantic Ocean according to R. Sterneck (copied from Defant, see text).

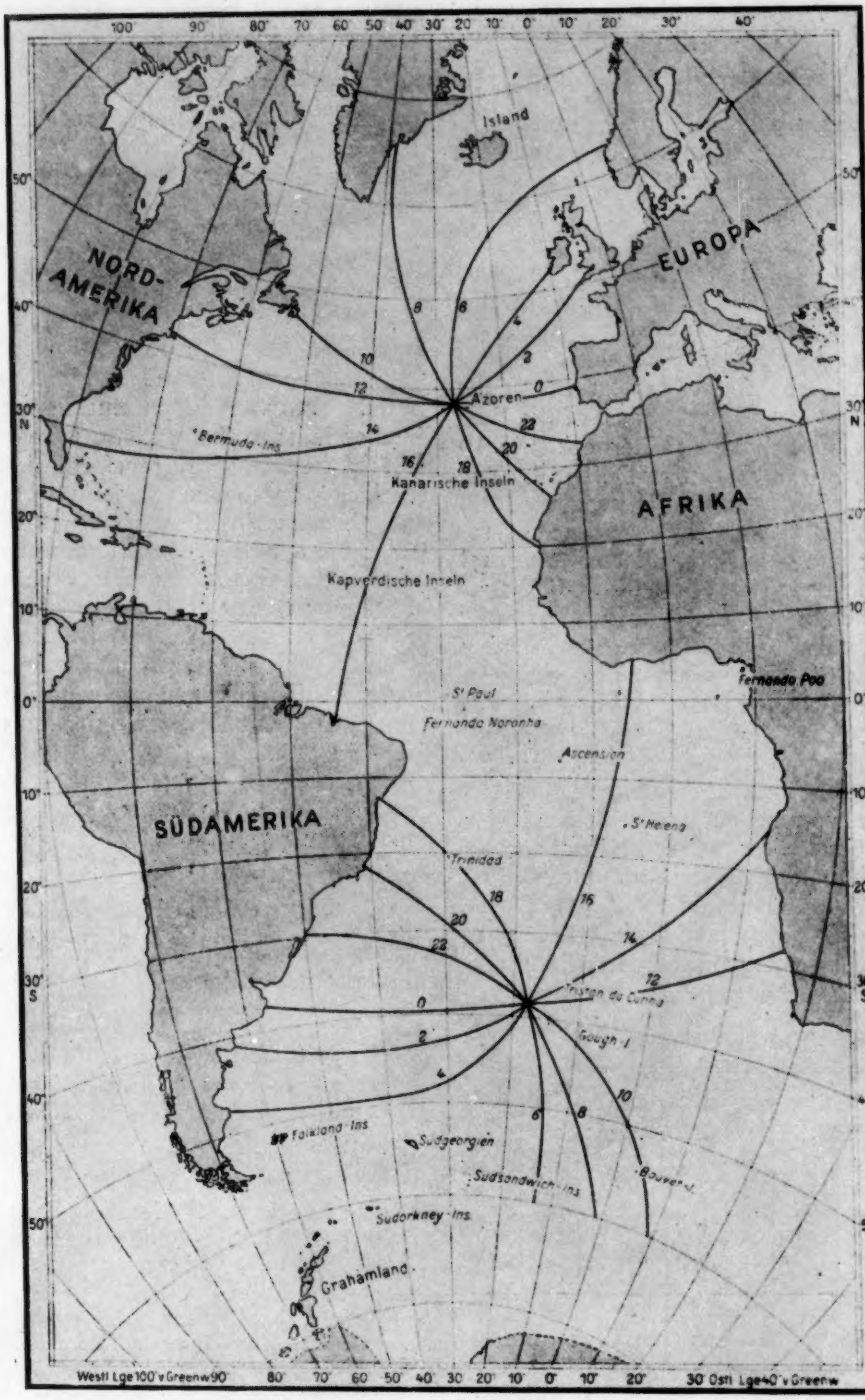

FIG. 11. Cotidal lines of diurnal tide in the Atlantic Ocean according to R. Sterneck (copied from Defant, see text).

in depths less than 700 meters (Table 4) becomes particularly striking in the more homogeneous water where maximum amplitude ratios $\left(\frac{\text{semidiurnal}}{\text{diurnal}}\right)$ reach 8.00. Still deeper (to 1050 meters), semidiurnal amplitudes diminished and the diurnal dominated, the minimum amplitude ratio $\left(\frac{\text{semidiurnal}}{\text{diurnal}}\right)$ being 0.185. Throughout the water column the range of amplitude ratios was approximately equivalent to that recorded at shallow water tidal stations (Table 11) encircling Station 3245.

A general good agreement between phases of observed currents in the upper layers of the Atlantic (30° S to 30° N) and phases of the tide, as given by the cotidal maps of Sterneck (Fig. 10 and 11), has been brought out by Defant.[23] The results are of particular interest because the total currents measured at the "Meteor" anchor stations appear to be of mixed tidal and Internal Wave origin, in which case it seems likely that both were of the same, or nearly the same, phase. On the other hand, internal vertical displacements of the water layers are not necessarily in phase with the associated Internal Wave current. Examination of data from the eight "Meteor" anchor stations in the Atlantic reveals that (for identical stations) times of maximum displacements and of maximum current velocities differ by as much as 6 hours for the semidiurnal and by as much as 12 hours for the diurnal. Regularity between the two may be indicated by data from two "Meteor" stations (where observed currents and vertical displacements may appropriately be compared) on the high seas where (Table 12)

TABLE 12

"Meteor" station	Mean vertical displacement			Mean current			Phase difference	
	Depth	12^h phase	24^h phase	Depth	12^h phase	24^h phase	Displacement	Current
288	75–250	10.3^h	14.6^h	0–150	10.4^h	13.6^h	4.3^h	3.2^h
147	50–150	4.7^h	12.8^h	0– 30	2.0^h	10.5^h	8.1^h	8.5^h

difference in phase between semidiurnal and diurnal vertical displacements (in approximately the same strata) was nearly equal to that between semidiurnal and diurnal currents. Information is too scanty for conclusions regarding general relationships between the phase of vertical displacements and the phase of current velocities throughout the ocean space, but the collective evidence strengthens the inference that the relationship between the average displacement vectors and tides at Station 3245 is not a chance result.

The Internal Wave theory of Fjeldstad has previously been tested by Fjeldstad[24] and Lek,[25] who using suitable observations from the Norwegian Fjords and from the waters of the Dutch Indies, respectively, obtained acceptable agreement between observed and theoretically computed results. The present investigation goes further in that the statistical treatments of results of the analytical transformations reveals the significant space characteristics of both observed and theoretical values to be closely identical. Complete agreement is not to be expected since at any time irregular influences (characteristic of all geophysical phenomena) may play a more or less important role, and in general support is given to the concept that observed vertical displacements are agreeably represented by the theoretical Internal Wave mechanism proposed by Fjeldstad.

Internal Wave propagation velocities, C_n, are computed from the parameter, λ, in the Fjeldstad equation, thus:

$$C_n = \frac{1}{\lambda_n} = \sqrt{\frac{g}{\lambda^2 g}}\,.$$

Values of $\lambda^2 g$ used in the first four Internal Wave integrations at Station 3245 were:

1st order = 0.01458
2nd order = 0.08178
3rd order = 0.15299
4th order = 0.34200,

and the ensuing propagation velocities (Table 13) are compared with those at two other North Atlantic stations ("Michael Sars" No. 68, 39° 20′ N, 50° 50′ W, 5400 meters depth;[26] "Atlantis" No. 3091, 34° 02′ N, 65° 54′ W, 5100

[23] Defant, Albert. "Die Gezeiten und Inneren Gezeitenwellen des Atlantischen Ozeans." *Deutsche Atlantische Expedition, "Meteor," 1925–1927*, VII, Part 1, 318 pp., 1932.

[24] Fjeldstad, J. E. "Internal Waves." Communication at General Assembly of the International Association of Physical Oceanography, Edinburgh, September 1936. (Assoc. Oceanog. Phys., *Proces-Verbaux*, No. 2, pp. 141, 142.) 1937.

[25] Lek, Lodewijk. "Die Ergebnisse der Strom- und Serienmessungen." *Report of the Snellius Expedition*, II, Part 3, 169 pp., 1938.

[26] Reference footnote 15.

meters depth [27]) and at a South Pacific station ("Snellius" No. 253a; 01° 47.5′ S, 126° 59.9′ E, 1800 meters depth [28]).

The first Internal Wave propagation velocity range of 42 cm sec. is reduced to 17 cm sec. for the three North Atlantic stations having depths in excess of 5000 meters. The lower velocity at "Snellius" Station 253a may reasonably be the result of its inferior depth of only 1800 meters. Ranges recorded for propagation velocities of Internal Waves above the second order (about 10 cm $sec.^{-1}$) are of doubtful significance

TABLE 13

Internal wave order	Station 3245	Station 3091	Station M.S.–68	Station S–253a
1	259	276	267	234
2	110	87	90	116
3	80	70	75	77
4	54	50	49	58

Velocities of propagation (cm $sec.^{-1}$) for first four Internal Waves computed for "Atlantis" Stations 3245 (25° 32′ N, 53° 45′ W) and 3091 (34° 02′ N, 65° 54′ W), "Michael Sars" Station 68 (39° 20′ N, 50° 50′ W), and "Snellius" Station 253a (01° 47.5′ S, 126° 59.4′ E).

in view of discrepancies entering into computation of the parameter $\lambda^2 g$.

The velocity diminution with increasing order, as brought out by Table 13, is an approximate harmonic progression, and from the weighted harmonic mean of the results fair approximation to the propagation velocities, C_n', of Internal Waves in the open ocean is given by:

$$C_n'(\text{cms sec.}^{-1}) = \frac{221}{n} \cdot$$

Discrepancies in this empirical representation chiefly affect the first two Internal Wave orders (+ 55 cm $sec.^{-1}$, 1st order; − 24 to + 5 cm $sec.^{-1}$, 2nd order); for higher orders, the differences appear irrevelant ($\mp$ 6 cm $sec.^{-1}$).[29]

The length of the lunar semidiurnal first order wave, L, having a propagation velocity of 221 cm $sec.^{-1}$ is:

$$L = 221 \times 12.45 \times 3600 = 99.05 \text{ km}.$$

Since the length of the semidiurnal tidal wave [30] is approximately 8800 km at a depth of 4000 meters (approximate mean depth of the oceans) the ratio of length of internal to tidal waves is in the vicinity of 1 to 100. Likewise the ratio of the mean depth of the oceans to length of the semidiurnal tidal wave is of the order of magnitude of 10^{-4} while that for the first Internal Wave is 10^{-2}.

Appendix 1

Temperature measurements at "Atlantis" Station 3245 (25° 32′ N, 53° 45′ W) between $02^h\,54^m$ January 23 and $04^h\,45^m$ January 24, 1939 (G.C.T.). Scaled values in each column based on samplings with 17 pairs of reversing thermometers; depths corrected from unprotected thermometer readings at 300, 800 and 1200 meter levels. Departures between computed observation depths and those measured by the hydrographic wire are given in Table 1. Sampling times are average for observations between the 100 and 1200 meter levels, maximum departure estimated not to exceed $\mp$ 3 minutes. Surface temperatures were taken separately and coincided with the 100 meter observation.

[27] Reference footnote 3.

[28] Reference footnote 25.

[29] The empirical equation gives 44 and 37 cm $sec.^{-1}$, respectively, for propagation velocities of 5th and 6th order Internal Waves as compared to 39 and 32 cm sec. computed from the parameter $\lambda^2 g$ at Station 3245.

[30] Defant, Albert. "Gezeitenprobleme des Meeres in Landnahe." *Probleme der Kosmischen Physik*, VI, Hamburg, 80 pp., 1925.

Depth	02^h 54^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23
0	23.65	23.65	23.80	23.80	23.85	23.95	23.90	23.90	23.90	23.90	23.90	23.90	24.05	24.25
100	21.90	21.52	22.20	21.93	22.09	22.18	22.47	22.07	22.37	22.42	22.05	22.28	21.59	21.67
150	19.48	19.20	19.28	19.17	19.27	19.40	19.60	18.83	19.15	19.35	19.05	19.50	19.05	19.10
200	18.30	18.24	18.31	18.20	18.10	18.13	18.19	18.10	18.11	18.04	18.02	18.15	18.08	18.09
300	17.42	17.67	17.71	17.62	17.48	17.47	17.46	17.46	17.37	17.37	17.43	17.47	17.41	17.50
400	16.50	16.73	16.77	16.57	16.45	16.48	16.39	16.44	16.34	16.34	16.47	16.68	16.49	16.65
500	14.74	15.29	15.31	15.01	15.07	14.86	14.89	14.83	14.79	14.80	14.74	15.00	14.97	15.11
600	12.89	13.24	13.46	13.18	13.27	13.11	13.15	13.06	12.99	13.20	12.83	13.26	13.11	13.33
700	11.14	11.16	11.30	11.08	11.30	11.17	11.19	11.12	11.10	11.26	10.67	11.04	10.85	10.91
800	9.02	9.26	9.21	9.25	9.17	8.88	8.93	9.01	9.03	8.98	8.64	9.04	9.00	9.07
900	7.63	7.69	7.73	7.75	7.71	7.65	7.68	7.80	7.77	7.75	7.68	7.80	7.76	7.82
1000	6.39	6.39	6.45	6.55	6.39	6.31	6.41	6.60	6.79	6.70	6.64	6.52	6.49	6.48
1100	5.71	5.75	5.75	5.70	5.70	5.69	5.68	5.79	5.87	5.81	5.84	5.82	5.76	5.79

Depth	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 23	00^h 00^m Jan. 24	00^h 00^m Jan. 24	00^h 00^m Jan. 24	00^h 00^m Jan. 24	04^h 54^m Jan. 24
0	24.25	24.20	24.20	24.15	24.10	24.10	24.10	24.10	24.10	24.10	24.10	24.00	23.90	23.90
100	22.35	22.14	21.74	22.05	21.90	22.15	21.60	22.20	22.04	21.93	21.75	21.16	21.75	21.44
150	19.46	19.46	19.10	19.06	19.02	19.28	19.18	19.18	19.40	21.08	19.12	19.10	19.15	19.11
200	18.19	18.25	18.00	17.98	18.00	18.14	18.10	17.98	18.13	18.11	18.17	18.07	18.10	18.04
300	17.56	17.58	17.55	17.35	17.40	17.39		17.38	17.39	17.39	17.45	17.45	17.45	17.45
400	16.69	16.67	16.55	16.32	16.38	16.37		16.40	16.43	16.53	16.53	16.54	16.61	16.64
500	15.06	15 00	14.99	14.87	14.90	14.85		14.90	14.91	14.83	14.87	14.85	15.10	15.05
600	13.39	13.28	13.14	13.20	13.10	13.13		13.06	13.10	13.05	12.95	13.03	13.20	12.95
700	11.02	11.11	11.01	11.08	10.98	10.98		11.03	10.91	11.05	10.94	10.73	10.99	10.90
800	9.13	9.30	9.22	9.15	9.08	9.20		9.15	9.18	9.21	9.16	9.00	9.01	9.00
900	7.88	7.77	7.74	7.70	7.69	7.70		7.68	7.68	7.68	7.58	7.61	7.56	7.68
1000	6.44	6.31	6.32	6.30	6.29	6.35		6.30	6.61	6.62	6.69	6.50	6.44	6.48
1100	5.74	5.75	5.76	5.73	5.66	5.69		5.70	5.73	5.69	5.68	5.63	5.63	5.74

PALEOCENE FAUNAS OF THE POLECAT BENCH FORMATION, PARK COUNTY, WYOMING

PART II. LIZARDS [1]

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(Communicated by WILLIAM B. SCOTT)

ABSTRACT

Based principally upon the study of fragmentary specimens from the Polecat Bench formation the following Paleocene lizards are described: *Exostinus? rugosus*, new species; *Provaranosaurus acutus*, new genus and species; *Peltosaurus jepseni*, new species; *Oligodontosaurus wyomingensis*, new genus and species; and *Haplodontosaurus*, new genus. The distribution of all Paleocene reptiles known from formations in North America is charted.

INTRODUCTION

THE fossil lizard materials upon which this paper is based were collected by Princeton Scott Fund expeditions while exploring Paleocene mammal localities in Park County, Wyoming. Most of the specimens are from the Silver Coulee beds of the Polecat Bench formation, the geology of which has been fully discussed by Jepsen (1930, pp. 490–491; 1940, pp. 231–238) in Part I of this series of reports upon the faunas of the Polecat Bench formation.

It is perhaps needless to refer to the meager character of the materials, consisting chiefly of dentary and maxillary bones with teeth. Upon such scanty evidence little can be accomplished in determining their true affinities. It is believed, however, that sufficient diagnostic characters have been found to distinguish them, and that new materials can be identified with them, and thus through future discoveries it is anticipated that all will be eventually characterized and classified within the suborder.

This collection, belonging to the Princeton Geological Museum, was placed in my hands for study through the generosity of my friend, Dr. Glenn L. Jepsen, who informs me that the field work of collecting the specimens was supported by the Scott Fund and by a cooperative grant from the Geological Society of America and from the American Philosophical Society. The illustrations were prepared by Mr. Sydney Prentice and Mrs. A. W. Awl.

Family IGUANIDAE Bonaparte, 1840

Genus EXOSTINUS Cope, 1873

Exostinus is a genus of uncertain family reference, although it has been provisionally included in the Iguanidae for a number of years. During this time new discoveries have been favorable to this assignment but its certain relationship may still be regarded as obscure. *Exostinus* now includes three species, *E. serratus* Cope from the Oligocene (Brule), *E. lancensis* Gilmore from the Late Cretaceous (Lance), and *E. rugosus* herein described.

Exostinus? rugosus, new species. Figs. 1, 2

Type.—Princeton no. 14559, posterior half of right maxillary bearing five teeth.

Referred specimens.—Princeton no. 14640, parts of both maxillaries, both dentaries, jugal, and fragmentary skull and jaw parts.

Distribution.—Princeton Quarry, Sec. 21, T 57 N, R 100 W, Park County, Wyoming; Silver Coulee beds, Polecat Bench formation.

FIG. 1. Posterior half of right maxillary of *Exostinus? rugosus*. Type, Princeton Mus. no. 14559. External view. Five times natural size.

Discussion.—A small iguanid lizard is distinguished from other forms in this collection of Paleocene fossils by the character of the ornamentation on the external surface of the type

[1] Published with the permission of the Secretary of the Smithsonian Institution.

maxillary, a series of small tubercular clusters that are without distinct arrangement, as shown in Fig. 1. The teeth on this specimen are pleurodont with subcylindric shafts. It is quite evident, although not too clearly shown by the present specimen, that the compressed crowns are bicuspid, consisting of a large posterior denticle with a smaller cusp in front. Shallow, longitudinal grooves on the external side of some of the teeth lead to the point of division between the denticles on the crown. These grooves are suggestive of somewhat similar conditions found on the tricuspid teeth of *Chamops segnis* from the Lance. In the latter, however, the grooves are more distinct and the longer ones are found on the inside of the teeth.

Princeton no. 14640, from the same quarry as the type, consists of parts of both maxillaries, both dentaries, jugal and a few fragmentary skull and jaw parts. None of the tooth bearing bones is completely preserved, hence the total number of teeth cannot be determined. One dentary shows evidence of 14 teeth but an unknown number are missing from the front of the series. Five teeth occupy a longitudinal space of 3 millimeters as in *Exostinus lancensis*. A scar on the outer posterior surface of the dentary indicates the extent of the anterior process of the coronoid as being to a point below the second tooth from the posterior end of the series, as in most Iguanidae. Biscuspid teeth are present in both upper and lower dental series. There are a few crowns, however, on which this bicuspid condition cannot be detected.

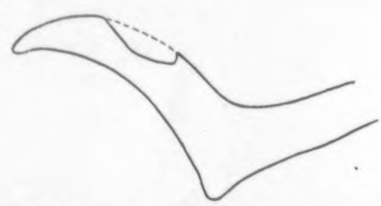

FIG. 2. Right jugal of *Exostinus? rugosus*. Princeton Mus. no. 14640. Lateral view. Five times natural size.

The jugal has the usual curved shape (Fig. 2) with a bluntly pointed triangular spur projecting backward from the posterior angle where the bone bends upward to form the posterior boundary of the orbit. The lower, outer surface of this bone is sparsely sculptured by a few short raised ridges that form an indefinite pattern. The type of sculpturing has a distinct resemblance to that found on the maxillary. This style of sculpturing on the jugal also distinguishes this species from *Exostinus serratus* Cope, which has the jugal covered with flat, quadrangular bony tubercles.

On the basis of the sculpturing of the maxillary and the jugal as in *Exostinus serratus* this specimen is provisionally referred to a species of the genus *Exostinus*. From the other species of the genus, *E. serratus* Cope and *E.? lancensis* Gilmore, the present form is distinguished at once by the bicuspid maxillary and dentary teeth as contrasted with the simple crowns in both of those species. The specific name *rugosus* is, therefore, proposed for its reception. The species name was suggested by the rugose sculpturing on the maxillary and jugal surfaces.

Family **VARANIDAE** Bonaparte, 1831

Dollo, in 1923, described a varanid lizard, *Saniwa orsmaelensis* from the Orsmael and Erquelinnes localities of Belgium. At that time he believed that the late Landenian (Sparnacian) faunas were of Paleocene age, but the close similarity of the Sparnacian and the early Wasatchian mammals and other considerations now lead to the belief that most if not all of the deposits at Orsmael and Erquelinnes should be assigned to the Eocene. As Simpson (1929) states, however, ". . . the fauna of Orsmael retains some special affinity with the Paleocene. . . ."

At any rate the Silver Coulee beds are older than the Wasatchian sediments of the Bighorn Basin, as demonstrated by stratigraphic position, and hence are probably older than the deposits yielding *Saniwa orsmaelensis*.

Provaranosaurus acutus, new genus and species

Type.—Princeton Mus. no. 14243, left maxillary bearing 11 teeth.

Distribution.—Princeton Quarry, Sec. 21, T 57 N, R 100 W, Park County, Wyoming; Silver Coulee beds, Polecat Bench formation.

Discussion.—The maxillary selected as the type has been prepared in relief on a small block of matrix and thus only the external side is accessible for study. Fortunately the most anterior tooth was sufficiently exposed on the inner side to show the pleurodont character of its attachment. The dentigerous portion of the maxillary which has both ends completely preserved has an overall length of 23 millimeters. There are 11 teeth present in the jaw, but it is quite evident that several are missing from the complete series, as shown in Fig. 3.

The teeth are pleurodont, widely spaced, (in contrast to the lack of diastemata in *S. orsmaelensis*), have slender crowns, and are round in cross section, with sharply pointed tips. All of the longer teeth are inclined backward, but none

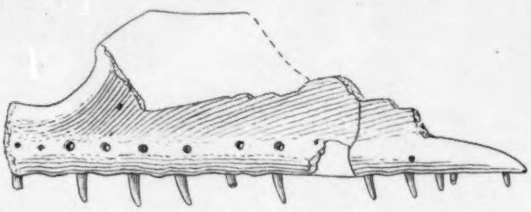

FIG. 3. Left maxillary of *Provaranosaurus acutus*. Type. Princeton Mus. no. 14243. Viewed from the left side. Three times natural size.

has the backward curvature found in the teeth of *Palaeovaranus* from the Phosphorites of France. The largest teeth are borne on the anterior half of the maxillary, and they gradually reduce in size posteriorly.

The anterior portion of a left dentary, Princeton Mus. no. 14561 is provisionally identified as pertaining to this same genus and species. The slender, sharp, simple crowned, widely spaced teeth, combined with the slenderness of the dentary as a whole all point to the correctness of such a conclusion. Toward the anterior end the dentary bends inward toward the symphysial contact. On the lower internal side the bone is deeply furrowed by Meckel's groove which runs to the symphysis. On the median external side is the usual row of foramina. The teeth are pleurodont with expanded bases as in varanids generally, but they lack the basal striations found in *Varanus*, *Saniwa* and *Parasaniwa*.

Method of implantation, shape, and wide spacing of the teeth are all features indicating varanid affinities and this genus is therefore tentatively referred to the family Varanidae. If correctly assigned it is a representative of the family that occupies an intermediate position geologically between the Late Cretaceous (Lance) *Parasaniwa* and the Eocene (Bridger) *Saniwa*. The straight, slender, sharply pointed teeth without basal striations distinguish *Provaranosaurus* from the other members of the family.

Family **ANGUIDAE** Bonaparte, 1831

Genus PELTOSAURUS Cope, 1873

Peltosaurus jepseni, new species.

Figs. 4, 5, 6, 7, 8

Type.—Princeton Mus. no. 14565, incomplete right maxillary bearing 9 teeth, posterior portion of the parietal, and one dermal scute.

Paratype.—Princeton Mus. no. 13371, left maxillary bearing 13 teeth.

Distribution.—Type specimens from Princeton Quarry, Sec. 21, T 57 N, R 100 W, Park County, Wyoming, Silver Coulee beds, Polecat Bench formation. Additional specimens from this site; also from the Rock Bench quarry beds, Park County, Wyoming; from the Lebo of the Crazy Mountain field, Montana; and from the Dragon formation, Emery County, Utah.

Discussion.—The present species is based on a study of twenty-three specimens, six in the National Museum and seventeen in the Princeton Museum collections, of which Princeton Mus. no. 14565 is selected as a type. This specimen is of interest as furnishing the first available information on the character of the scutellation of these Paleocene lizards. The close resemblances found in the dentition, scutellation of head and body to the corresponding parts of those of *Peltosaurus granulosus* Cope confirms the correctness of the original assignment of some of the National Museum specimens to the genus *Peltosaurus* on meager materials (Gilmore 1928, p. 137).

The parietal consists of the posterior half with the right posterior process, the left is entirely missing. The superior surface is plane and except for a wide smooth band posteriorly is covered by bony scutes that are fully coalesced to the underlying bone. As shown in Fig. 4, the

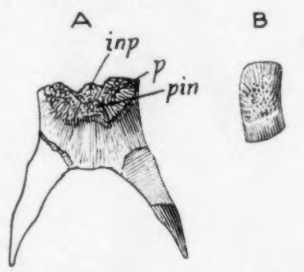

FIG. 4. Parietal and dermal scute of *Peltosaurus jepseni*. Type. Princeton Mus. no. 14565. *A*, posterior portion of parietal; *B*, dermal scute; *inp*, interparietal scute; *p*, parietal scute; *pin*, postinterparietal scute. Both figures three times natural size.

scutal area consists of two large parietal scutes that are separated on the midline by the interposition of a narrow interparietal. The latter is joined posteriorly by a small subtriangular postinterparietal. The arrangement of these scutes, insofar as they can be judged in their incomplete state, are in close agreement with those of *P. granulosus*, differing only in size, proportions, and the style of ornamentation of their dorsal surfaces. *P. granulosus* has a granular sculpture of both head and body scutes, whereas in the present specimen, more especially the parietal scutes, are ornamented by a series of low radiating ridges with narrow intervening valleys. These ridges do not form a distinct pattern although the more conspicuous of the ridges have a decided trend backward and outward from the center of the scute as shown in Fig. 4. The posterior median border of the parietal between the divergent posterior processes is broadly hollowed out, as contrasted with the deep U-shaped notch in *P. granulosus.*

The dermal body scute, see Fig. 4-*B*, has the usual quadrangular shape with a narrow smooth, articular band across the anterior end. The remaining dorsal surface has a sculpture resembling that of the skull scutes, but with the pattern less well defined.

The type maxillary which bears nine teeth is slightly incomplete at both ends. In size, outline, and surface marking it is in complete accord with the more perfect paratype, Princeton Mus. no. 13371, on which the description to follow is based.

There are 13 teeth present in the paratype, but as shown in Fig. 5, it is clearly evident that two

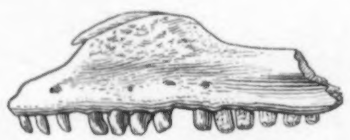

FIG. 5. Left maxillary of *Peltosaurus jepseni.* Paratype. Princeton Mus. no. 13371. External view. Three times natural size.

are missing, thus 15 teeth would constitute the complete maxillary series, one tooth less than in *P. granulosus* which has 16 to 17, or *Melanosaurus* which has 16. The teeth are pleurodont, stout, shafts compressed fore and aft with flattened sides, and closely spaced in the jaw. The crowns are bluntly wedge-shaped with the longer bevel internal. On some of the crowns there is faint evidence of striae running downward at right angles to the cutting edge, but this sculpturing soon disappears with wear. The largest teeth are in the center of the series but they diminish both in size and length toward the ends of the maxillary. Upper teeth appear indistinguishable from the lower.

Over all the maxillary has a greatest length of 15.3 millimeters and the 15 teeth occupy a space of 13 millimeters.

Viewed laterally (see Fig. 5) the maxillary presents a narrow smooth surface paralleling the dentigerous border which is perforated by the usual row of foramina. Above this smooth area on the anterior half the surface is slightly roughened. A similar surface on the maxillary of *P. granulosus* marks the attachment of the lowermost of the dermal scutes which form such a conspicuous feature of the skull in that species.

In an earlier paper, an incomplete right maxillary bearing 8 teeth, U. S. N. M. no. 10920 was assigned to the genus *Peltosaurus*, (Gilmore 1938, p. 22) but without specific designation. In view of its close resemblance both in size and other characteristics it can now be definitely identified as pertaining to the present species. This specimen which comes from the Lebo (Fort Union No. 2) Paleocene, Sweetgrass County, Montana, considerably extends the known geographical range of the present species.

The lower jaw of *P. jepseni* is represented by several fragments of rami from the same locality and geological horizon as the type and paratype. Also in the Princeton Mus. collections are three specimens, nos. 14577, 14578, and 14579, from a lower level, the Rock Bench quarry beds, pertaining to this form. In the National Museum collections there are three incomplete dentaries, nos. 10444, 10446, and 10811, from the Lebo (Fort Union No. 2) of Sweetgrass County, Montana, that can also be referred to this genus and species.

One of the Silver Coulee specimens, a nearly complete right dentary, Princeton Mus. no. 14245 (Fig. 6) shows the complete dental series

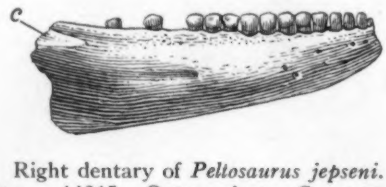

FIG. 6. Right dentary of *Peltosaurus jepseni.* Princeton Mus. no. 14245. Outer view. *C*, coronoid scar. Three times natural size.

to consist of not less than 17 teeth as contrasted with 21 in *P. granulosus.* These teeth occupy a space 12.3 millimeters in length. A scar on the upper posterior surface of the outside of the dentary indicates the point of overlap of the outer anterior process of the coronoid. Beneath it is the scar for the overlap of the broadly rounded end of the surangular. The portion of a jaw illustrated in Fig. 7 shows the coronoid to sit astride the dentary as in *P. granulosus* with its tapering inner prolongation terminating opposite next to the last tooth. The splenial is the usual thin bone that covers Meckel's groove. Its ventral contact cannot be traced and the anterior end is missing. The splenial is perforated near its middle by a longitudinally elongated foramen.

The relatively longer and more closely spaced teeth as compared with those of *P. piger* are clearly indicated in Fig. 7.

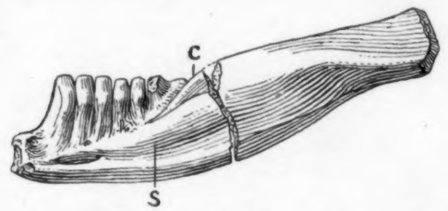

FIG. 7. Portion of a right ramus of *Peltosaurus jepseni*. Princeton Mus. no. 14244. Viewed from the inner side. *C*, coronoid; *s*, splenial. Doubtful contact at the median break. Three times natural size.

Two dentary fragments containing teeth, U. S. N. M. Nos. 16579 and 16583 from the Dragon formation, Paleocene, in the Manti National Forest, Emery County, Utah, are provisionally identified as pertaining to the present genus and species. These teeth are in perfect agreement with those described from the Paleocene of northern localities, both as to size and other characteristics.

A single thoracic vertebra, preserved in a small block of matrix in close proximity to a considerable number of dermal scutes of the *Peltosaurus jepseni* type, is provisionally identified as pertaining to that genus and species. If correct in this assumption it furnishes the first information had of the vertebral column. Only the ventral side is available for study at this time (see Fig. 8). The centrum is tapering, having a closer resemblance to the vertebra of *Iguana* than to the

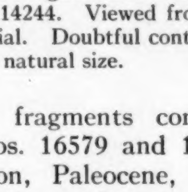

FIG. 8. Thoracic vertebra of *Peltosaurus jepseni*. Princeton Mus. no. 14641. Ventral view. Five times natural size.

more quadrangular centra of *Peltosaurus granulosus*. The median, flattened ventral surface is defined by shallow longitudinal grooves on either side. The centrum as a whole is depressed, the cup and ball are transversely ovate, the latter set off by a shallow annular groove on the ventral side. The dispophyses project outward from the anterior lateral angles of the centrum but do not extend below its ventral border. The centrum has a greatest length of 4 mm., and a greatest width across the diapophyses of 3.2 mm.

The genus *Peltosaurus* now contains the following species, *P. granulosus*, *P. abbotti* both from the Oligocene, and *P. piger* from the Lance formation. *Peltosaurus jepseni* may be distinguished from the Oligocene species by its slightly smaller size and differences in the sculpture of the dermal scutes of head and body as previously described. The parietal also displays a broad, shallow notch on its posterior median border as contrasted with the deep U-shaped notch in *P. granulosus*. There also appear to be fewer teeth but due to the paucity of materials this observation needs verification.

From *P. piger*, the present species may be distinguished by the more slender form of its teeth, and by the greater length of their protrusion beyond the alveolar borders.

This species is named for Dr. Glenn L. Jepsen in appreciation of his outstanding contributions to our knowledge of the mammalian faunas from this same Wyoming area.

SAURIA OF UNKNOWN FAMILY REFERENCE

Oligodontosaurus wyomingensis, new genus and species. Fig. 9

Type.—Princeton Mus. no. 14246, consists of a left ramus bearing a complete dentition.

Distribution.—Princeton Quarry, Sec. 21, T 57 N, R 100 W, Park County, Wyoming, Silver Coulee beds, Polecat Bench formation.

Discussion.—This species is based on a left ramus that lacks its articular end posterior to the coronoid process. As preserved the ramus has a greatest length from end to end of 6.8 millimeters. The specimen has been reliefed on a small block of matrix and thus only the internal side is available for study at this time. The complete dental series consists of 9 homodont teeth, all present except the crown of the most anterior one.

These are subpleurodont in manner of attachment and the 9 teeth occupy a longitudinal space of 4.8 millimeters. The teeth are transversely compressed with lance-shaped crowns. The last tooth is the most robust of the series; the other teeth reduce in size anteriorly. The most an-

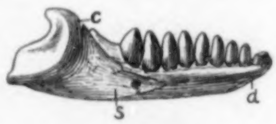

FIG. 9. Left ramus of *Oligodontosaurus wyomingensis*. Type. Princeton Mus. no. 14246. Internal view. *C*, coronoid; *d*, dentary; *s*, splenial. Five times natural size.

terior tooth situated on the very tip of the dentary has an enlarged base. The inclined shelf to which the teeth are attached is relatively narrow, occupying less than one half the total depth of the dentary. With the exception of there being fewer teeth in the series, their configuration and method of attachment have their closest resemblance in *Lanceosaurus hatcheri* from the Lance formation (Gilmore, 1928, p. 160, Fig. 104, p. 26, Fig. 8).

The coronoid is relatively stout, with truncated upper extremity, and strengthened on the inner side by a low, rounded ridge that originates well toward the top and extends downward with a decided backward curve on the lower half of the ramus where it merges with the prearticular. The inner anterior process of the coronoid that laps the dentary ends on the line of the posterior border of the last tooth.

The splenial appears to be very short, apparently terminating posterior to the mid length of the dentary as shown in Fig. 9. None of the other structural details of the posterior portion of the jaw can be certainly determined.

The diminutive size of the type coupled with the reduced number of teeth in the dentary with an enlarged posterior tooth and a reduced splenial constitute a series of characters sufficient to distinguish fully this genus and species from all known Sauria. At this time no clue has been obtained as to its proper family assignment.

Haplodontosaurus, new genus

Genotype, *Harpagosaurus excedens* Gilmore, Mem. Nat. Acad. Sci., vol. 22, No. 3, p. 157, Fig. 99, 1928.

The new genus *Haplodontosaurus* is proposed for the reception of the species *excedens*. Originally this species was provisionally referred to the genus *Harpagosaurus*. Its removal is brought about by a re-examination of the type in connection with the study of a complete maxillary (Princeton Mus. no. 14560) the dentition of which displays such close resemblances to the teeth of the type of *H.? excedens* as to suggest their specific identity. If this conclusion is correct it permits comparison to be made with the type of *Harpagosaurus parvus* based on a maxillary from the Lance formation. This specimen (see Fig. 11) has a series of acutely pointed

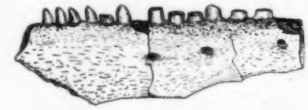

FIG. 10. Right dentary of *Haplodontosaurus excedens*. Type. U. S. N. M. no. 10447. Lateral view. Five times natural size. After Gilmore.

FIG. 11. Right maxillary of *Harpagosaurus parvus* Gilmore. Type. U. S. N. M. no. 10803. Lateral view. About five times natural size. After Gilmore.

pleurodont teeth with cylindrical shafts and a long narial border that is moderately inclined to the horizontal; in *Haplodontosaurus excedens* the pleurodont teeth are bluntly pointed with shafts slightly flattened fore and aft, and the narial border is short and steeply inclined (see Fig. 12) indicating a high blunt muzzle as contrasted with the more attenuated nose in *Harpagosaurus parvus*. Mention should be made that this re-study of the type of *excedens* discloses it to be a dentary, not maxillary, as originally identified. This is indicated by the convex outer surface of the bone and the presence of a small portion of Meckel's groove.

HAPLODONTOSAURUS EXCEDENS (Gilmore, 1928)

In the Princeton lizard collection there are four specimens (nos. 14560, 14563, 14567 and 14569) identified as pertaining to the present genus and species. All are from the Silver Coulee beds,

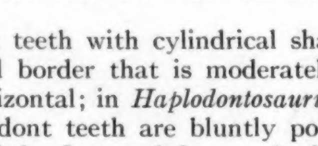

FIG. 12. Right maxillary of *Haplodontosaurus excedens*. Princeton Mus. no. 14560. Lateral view. Five times natural size.

Polecat Bench formation, Paleocene, and all were found in the Princeton Quarry, Sec. 21, T 57 N, R 100 W, Park County, Wyoming.

The most perfect specimen, a complete maxillary illustrated in Fig. 12, has a greatest length over all of 8 millimeters. There are 12 teeth preserved in the maxillary but it is clearly evident that the full complement would consist of 17 teeth. This fact furnished a further distinction between the two genera, as the maxillary of *Harpagosaurus parvus* carries only 14 teeth. The form of the maxillary is clearly depicted in Fig. 12 and thus requires no further description.

Specimen Princeton Mus. no. 14563 is a right maxillary lacking its anterior end. In size and all other characteristics it is in complete accord with the maxillary illustrated in Fig. 12.

The third specimen, Princeton Mus. no. 14567, is a small section of a left dentary bearing 4 teeth. These teeth have the fore and aft sides of the shafts slightly flattened as in the type of the species. The crowns are more acutely pointed than those of the available maxillae. The fourth specimen, Princeton Mus. no. 14569, consists of the anterior end of a left maxillary carrying 6 or more teeth. It contributes no additional information concerning the species.

Summary

Most of the Paleocene lizard specimens described herein were collected from one locality designated "Princeton Quarry" and located in Sec. 21, T 57 N, R 100 W, on the east side of Sand Coulee basin, Park County, Wyoming. This quarry has produced several hundred mammalian specimens, including a complete skeleton, a number of articulated skulls and jaws, vertebral columns, and limbs. Among the mammals Jepsen (1940, p. 236) has recognized

Known Distribution of North American Paleocene Reptiles

	Mantua (Wyo.)	Puerco (N. Mex.)	Dragon (Utah)	Torrejon (N. Mex.)	Rock Bench (Wyo.)	Lebo (Mont.)	Ravenscrag (Sask.)	Paskapoo (Alberta)	Melville (Mont.)	Silver Coulee (Wyo.)	Bear Creek (Mont.)	Clark Fork (Wyo.)
Sauria												
Iguanidae												
Exostinus? rugosus										x		
Varanidae												
Provaranosaurus acutus										x		
Anguidae												
Peltosaurus jepseni			x		x	x				x		
P. sp.				x								
Family reference uncertain												
Oligodontosaurus wyomingensis										x		
Haplodontosaurus excedens						x				x		
Machaeosaurus torrejonensis				x								
Harpagosaurus? silberlingi						x						
Serpentes												
Helagras prisciformis		x		x								
Crocodilia												
Leidyosuchus multidentatus				x								
Allognathosuchus mooki		x										
Allognathosuchids undesc.					x							x
Crocodilids undesc.	x									x		
Rhynchocephalia												
Champsosaurus puercensis				x								
C. saponensis		x		x								
C. australis		x										
Champsosaurids undesc.	x				x	x	x		x	x	x	x

KNOWN DISTRIBUTION OF NORTH AMERICAN PALEOCENE REPTILES—*Continued*

	Mantua (Wyo.)	Puerco (N. Mex.)	Dragon (Utah)	Torrejon (N. Mex.)	Rock Bench (Wyo.)	Lebo (Mont.)	Ravenscrag (Sask.)	Paskapoo (Alberta)	Melville (Mont.)	Silver Coulee (Wyo.)	Bear Creek (Mont.)	Clark Fork (Wyo.)
Chelonia												
Pleurosternidae												
Compsemys parvus		x		x								
C. vafer		x										
C. puercensis		x										
C. torrejonensis				x								
Baenidae												
Baena escavada				x								
B. sp.		x		x								
Dermatemydidae												
Adocus hesperius		x										
A. substrictus				x								
A. onerosus				x								
A. annexus				x								
Hoplochelys crassa		x										
H. bicarinata		x										
H. laqueata		x										
H. saliens				x								
H. paludosa				x								
H. elongata				x								
H. caelata						x						
Plastomenidae												
Plastomenus acupictus				x								
P. torrejonensis				x								
P. sp.		x		x								
Emydidae												
Clemmys backmani							x					
Trionychidae												
Aspideretes sagatus		x										
A. puercensis		x										
A. reesidei		x										
A. vegetus		x										
A. quadratus		x										
A. perplexus		x										
A. singularis				x								
A. superstes								x				
A. cf. *subquadratus*							x					
A? nassau									x			
A. sp.				x								
Conchochelys admirabilis		x										
Amyda eloisae		x										
Platypeltis antiqua				x								
Chelonids undesc.	x		x		x			x		x	x	x

nine orders, seventeen families, and twenty-eight genera, and states that there are others, as yet unstudied, mammalian forms represented. The quarry has yielded also at least two kinds of amphibia, one represented by a complete skull and jaws and part of the vertebral column. These will be described in another part of this series of publications upon the faunas of the Polecat Bench formation.

In addition to the three families and five genera and species described herein, there are only two other species of Paleocene lizards known from the United States. These are *Harpagosaurus? silberlingi* from the Lebo of Montana (Gilmore 1938, pp. 24–25), and *Machaeosaurus torrejonensis* from the Torrejon of New Mexico (Gilmore, 1928, pp. 155–156). That there were other as yet undescribed members of the Sauria in the

Paleocene is indicated by fragmentary specimens in both the Princeton and the United States National Museum collections but these materials are too meager for characterization.

In the belief that a tabulation of the reptilia known from the Paleocene of North America will be useful, the following chart is presented to summarize the geological distribution of the various forms:

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STUDIES OF LIVING NERVES. VIII. HISTORIES OF NERVE ENDINGS IN FROG TADPOLES SUBJECTED TO VARIOUS INJURIOUS TREATMENTS[1]

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CONTENTS

ABSTRACT

Case histories are presented of individual nerve endings of terminal arborizations of myelinated fibers in frog tadpoles subjected to various kinds of injurious treatments. Electric shocks, starvation, chloretone anesthesia, wound infliction, insulin, and heat have each been used to induce nerve ending irritation. Swelling, retraction, and variable amounts of degeneration characterize markedly irritated endings. Reduction of swelling, extension, and branching characterize endings in process of recovery. Changes associated with chronic neuritis, such as are induced by starvation, are essentially similar to those associated with acute neuritis, such as are induced by electrical injury.

Examples are also presented of the behavior of rapidly growing nerve tips in young regenerating zones, as these are subjected to acute irritative treatments of several kinds. In regenerating zones several weeks old during the later stages of myelination, nerve endings of terminal arborizations exhibit slow adjustments of retraction, extension, and branching. These are quite like similar adjustments that take place in normal zones of young growing tadpoles.

It is clear from these observations that nerve ending patterns are not necessarily fixed and stable. The changed conditions imposed by experimental injuries often cause marked adjustments of the endings which result in new patterns. Such adjustments probably also occur at some synapses between nerve cells within the central nervous system.

Illustrative ciné-photomicrographs have been obtained.

[1] Aided by a grant from the Penrose fund of the American Philosophical Society and a grant from the American Association for the Advancement of Science.

INTRODUCTION

DIRECT observations of nerve fibers in living frog tadpoles may be made. In favorable cases the delicate endings of cutaneous terminal arborizations of myelinated fibers may also be discerned. If the same nerve endings in a tadpole are watched from day to day a fairly complete record can be secured of any changes that may take place. Some records of this type have already been published. These reveal nerve ending adjustments in tadpoles during rapid growth in size (Speidel, '42) and also in tadpoles during and following irritative treatments with alcohol, metrazol, and other irritants (Speidel, '36, '40, and '41).

Additional case histories are presented in this account which show the nerve ending changes in tadpoles subjected to various experimental injuries. The acute type of injury and recovery is well illustrated by the electric shock experiments; the chronic type by the starvation experiments, and slow adjustments to a changing terrain by the regeneration experiments. Examples are also given of nerve ending behavior in tadpoles approaching metamorphosis and in tadpoles treated with insulin, chloretone, and heat.

Although a few observations on rapidly advancing nerve endings are described, this account deals chiefly with the mature resting endings of terminal arborizations of myelinated fibers. Endings of this type are concerned in the mediation of nervous activities of relatively refined nature. They are present not only at the skin but also at synapses between nerve cells within the central nervous system. Modifications of nerve endings, therefore, may cause profound functional effects on general nervous activities.

Tadpoles of *Pseudacris feriarum* and *Hyla crucifer* were used in these experiments. During microscopic examination an animal was placed in a special upright chamber and kept temporarily immobilized by weak chloretone solution. Ciné-photomicrographs were made from many of the experimental animals. Several of the illustrations are based upon motion picture records.

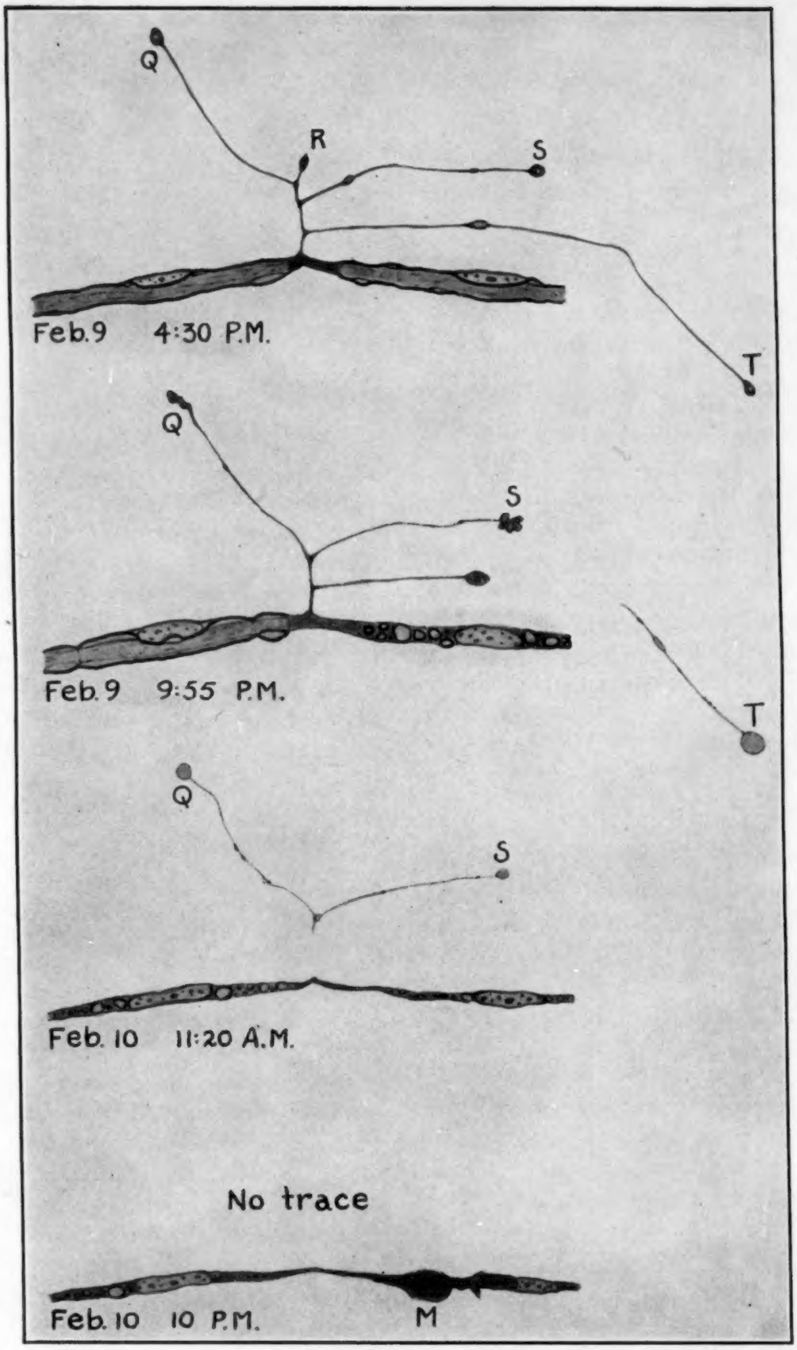

FIG. 1. Degenerative changes of the endings of a terminal arborization of the distal stump of a severed nerve fiber. Tadpole no. 1919, nerve fiber cut on February 9th at 4:18 P.M. The wound was some distance from the part of the fiber illustrated, a condition which ruled out the possibility of direct regional traumatic influences. Trophic changes quickly became visible within the first half hour. At 4:30 P.M. a vacuole was visible near the center of each of the four end bulbs. By 9:55 P.M. ending *R* had disappeared; the branch ending in *T* had suffered autotomy of its distal portion; and ending *S* was swollen and irregular in contour. One of the myelin segments had broken up into globules and the other was in process of fragmentation. On February 10th at 11:20 A.M. endings *Q* and *S* were still recognizable though they were disjoined from the remains of the main nerve fiber. The branches were very tenuous. They were characterized in some places by degenerative granules. By 10 P.M. there was no longer any trace of the terminal arborization. A macrophage (*M*) was active in ingesting myelin and axis cylinder remnants from within the neurilemma tube.

Complete Degeneration of Nerve Endings of Terminal Arborizations

Either complete or incomplete degeneration may be exhibited by terminal arborizations of injured nerve fibers. Cases of complete degeneration sometimes occur spontaneously in the tadpole's tail, particularly as the time for metamorphosis approaches. Other cases have been noted in animals subjected to irritative treatments of appropriate severity, as after treatment with electricity, metrazol, alcohol, and insulin.

The principal steps in nerve ending degeneration are also readily seen in the distal stump portion of a sectioned myelinated fiber. In the example given (Fig. 1) a young terminal arborization arising at a node of Ranvier is shown as it undergoes complete trophic degeneration. The sketches show the condition of the nerve endings at the following intervals after the cut was made: 12 minutes, 5½ hours, 19 hours, and 30 hours. The regressive changes include early vacuolation of the end bulbs, swelling, development of irregular end bulb contours, granulation, and fragmentation of the branches.

Other records of terminal arborization degeneration have been obtained. Essentially the same sequence of changes is exhibited whether the degeneration is induced by nerve section or by other means.

Histories of Nerve Endings in Tadpoles Subjected to Electric Shocks

With the electric current practically any degree of irritation or injury to tadpole tissues may be induced. Very severe treatments cause death. Severe treatments which are not lethal may bring about the degeneration of variable amounts of nerve substance. Other tissues are also conspicuously damaged, particularly the muscle and epithelium. More moderate treatments may cause visible nerve irritation without being followed by any loss of nerve substance. Mild treatments may induce little or no nerve change.

A severely injured fiber may degenerate with destruction of both axis cylinder and myelin sheath. Its nerve endings are also lost. A less severely injured fiber may lose a number of its most distal myelin sheath segments even though the axis cylinder survives. The terminal arborization endings of such a fiber may, or may not, survive. Moderately injured fibers may exhibit swelling of the myelin sheath. This is occasionally accompanied by some loss of nerve ending substance. Mildly irritated fibers may develop temporary vacuoles between the myelin sheath and axis cylinder. Nerve endings of such fibers usually remain fairly constant, though some end bulbs may exhibit swelling.

A fine example of nerve fiber behavior after electric shock treatment is illustrated (Fig. 2). The injury in this case was moderately severe, enough to induce acute irritative effects in the nerve fiber figured. Swelling of the end bulbs and some loss of nerve ending substance ensued. The older more massive myelin sheath segments survived, although a young terminal one degenerated. Three days of recovery was sufficient to allow the development of a pattern of endings somewhat different from the original pattern at the time of the injury.

An even greater degree of injury may sometimes be induced in some of the nerve fibers of electrically shocked tadpoles. Particularly interesting fibers are those which lose some of their distal myelin sheath segments without, however, degeneration of the corresponding axis cylinder portion. Two regions of such a fiber are illustrated (Figs. 3 and 4). The first of these (Fig. 3) pictures three degenerating myelin segments together with the remains of two side branches at former nodes of Ranvier. Complete loss of the side branches followed. Myelin debris obscured somewhat the exact condition of the axis cylinder. Nevertheless, a sure indication that it survived was afforded by the survival of one of its terminal endings that emerged from the most distal myelin sheath segment. This feature is illustrated in Fig. 4, which also reveals the steps of recovery of the terminal branch during the eleven days following the injury.

Rapidly regenerating nerve tips are likewise readily affected by electric shock treatments. Several excellent cases have been watched in newly regenerated zones a few days after the tip of the tail has been cut off. One example is presented (Fig. 5) which clearly indicates that treatments of moderate severity are sufficient to stop an advancing growth cone temporarily. Furthermore, growth cones are affected by treatments mild enough to cause no visible change in the resting nerve endings in the normal unoperated tail zone of the same tadpole.

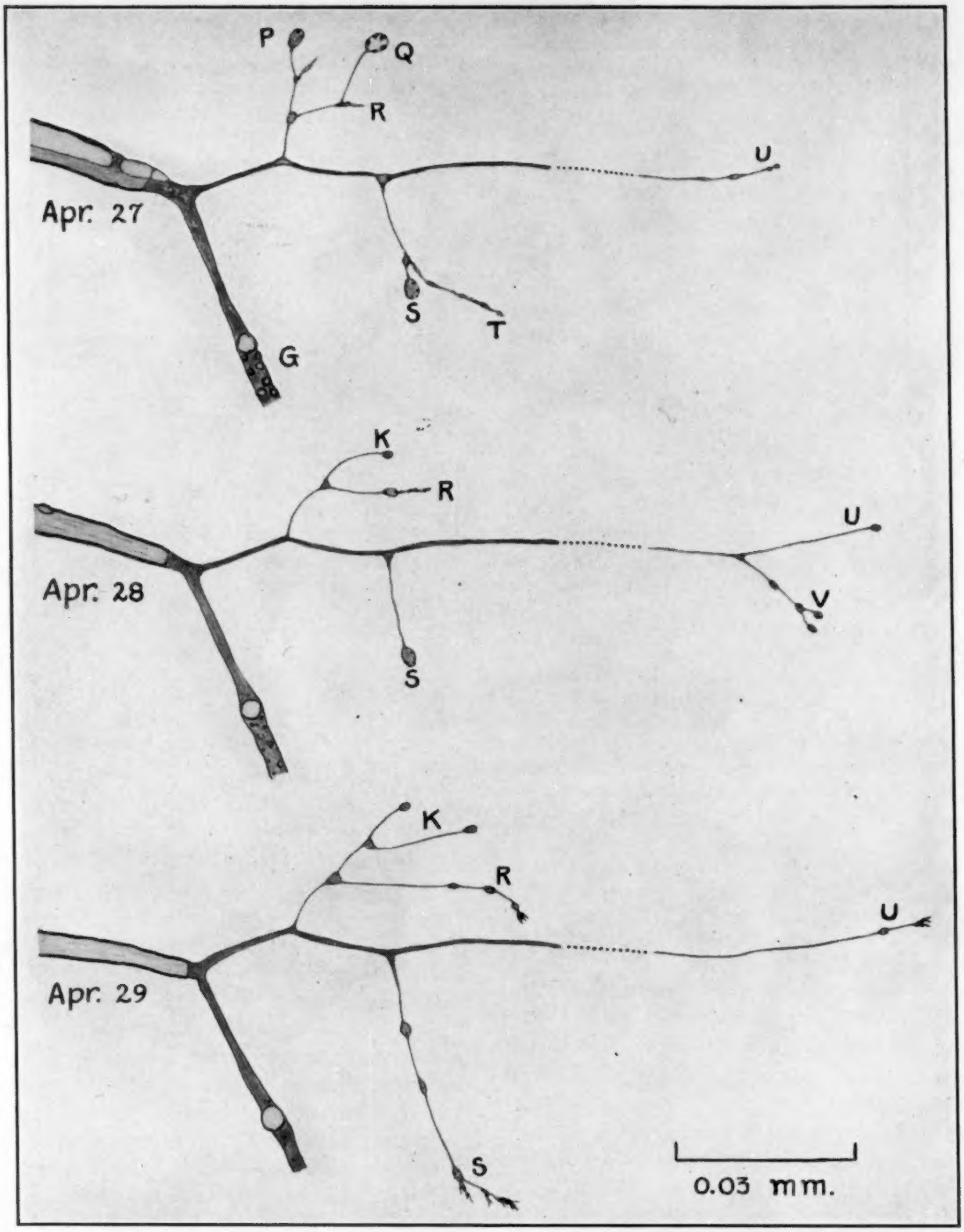

FIG. 2. Marked irritation of the endings of a terminal arborization following electric shock treatments and the subsequent steps of recovery. Tadpole no. 2432, subjected to a series of electric shocks on April 26th. The sketches are drawn exactly to scale from ciné-photomicrographic records. On April 27th the endings *P*, *Q*, and *S* were markedly swollen; *T* was degenerating and *R* was retracting. The myelin segment was greatly swollen, its diameter being more than twice that of the enclosed axis cylinder. The myelin globules at *G* represent the remains of a young delicate myelin segment which was just becoming differentiated on April 26th at the time of the injury. On April 28th endings *P*, *Q*, and *T* were no longer discernible, but new branches were present at *K* and *V*. Marked reduction of the myelin segment had taken place, so that it appeared essentially normal. By April 29th ending *V* had disappeared but ending *K* had branched and grown. Endings *R*, *S*, and *U* had all grown and at the time of observation each was provided with an active growth cone tip. (The dotted line indicates that a part of the length of the branch ending in *U* has been omitted from the drawing.) A distance of 0.03 mm (30 microns) is indicated below.

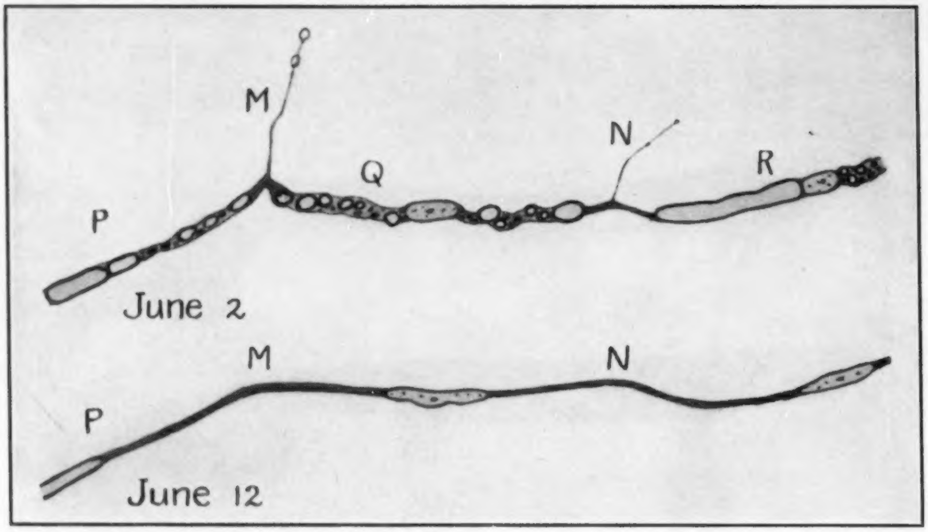

FIG. 3. Severe irritation of a myelinated fiber resulting from electric shock treatments with subsequent myelin segment degeneration and elimination of collateral branches. Tadpole no. 2452, subjected to a series of electric shocks on May 31st and June 1st. The injury was sufficient to induce breaking up of the myelin sheath of the 9 most distal segments of the fiber illustrated. *Q* represents the 4th myelin segment from the end, *P* the 5th, and *R* the 3rd. On June 2nd these segments exhibited fragmentation. At *M* and *N* are the greatly reduced remnants of what were terminal arborizations before the injury. By June 4th these had suffered complete elimination. The main axis cylinder portion of the fiber, however, survived. A much later condition of the fiber on June 12th is shown. New myelin segments were present on the proximal part of the fiber, just reaching the field illustrated at *P*. Collateral branches did not again develop at the former sites, *M* and *N*. (The history of the most distal part of this fiber is presented in Fig. 4.)

Histories of Nerve Endings in Starved Tadpoles

General tissue injury progressively develops in tadpoles subjected to starvation. Typical irritative changes become discernible in nerve fibers and their endings. Marked irregularities may characterize the surface epithelium of the tail if the starvation period is prolonged. A chronic state of irritation is set up.

Nerve endings of irritated myelinated fibers may display swelling, retraction, and loss of nerve substance by degeneration. If the starvation period is not too long recovery readily takes place. The endings again become normal in appearance and some growth adjustments may occur.

The first case illustrated (Fig. 6) shows the changes in three endings of a young terminal arborization over a period of 12 days. During the first starvation period the endings retracted. This was followed by some growth and extension after food was made available. A second starvation period again initiated regressive changes in the endings.

The second case (Fig. 7) shows the changes in an ending belonging to a terminal arborization of the same myelinated fiber as that of the preceding figure (Fig. 6). The arborization in this case was located more distally along the fiber. As before regressive changes were exhibited by the ending during the periods of starvation. During the period of recovery after the ending had grown out some distance, however, retraction again occurred even though the food conditions at this time were suitable for further growth. This is merely an indication that an individual ending may undergo regressive change at the same time that other endings are either advancing or at least maintaining their positions. This point has been clearly brought out by some prolonged histories of growing terminal arborizations previously reported (Speidel, '42).

As a result of the chronic irritation of prolonged starvation, an end bulb may become greatly swollen. It may then suffer granular degeneration; or it may break away from the nerve ending and undergo autolysis; or it may suffer autotomy and be ingested by a macrophage. An interesting

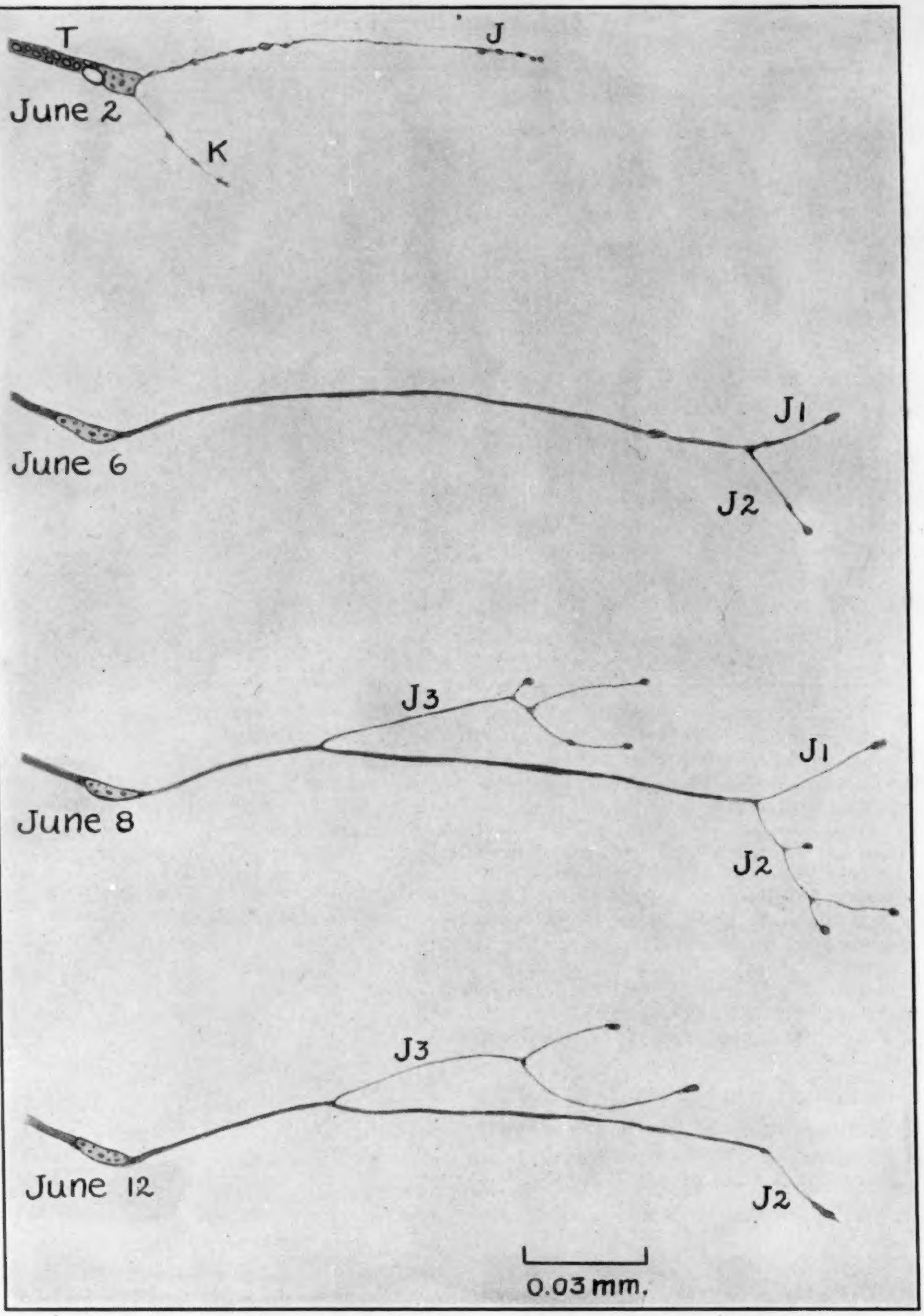

FIG. 4. Severe irritation of the terminal branches of a myelinated fiber resulting from electric shock treatments and the subsequent steps of recovery. Tadpole no. 2452, subjected to a series of electric shocks on May 31st and June 1st. The injury was sufficient to induce breaking up of the nine most distal myelin sheath segments. The sketches are drawn exactly to scale from ciné-photomicrographic records. On June 2nd two delicate irritated branches (*J* and *K*) were visible emerging from the degenerating terminal myelin segment (*T*). The sheath cell of this segment is located at the base of the two branches. During the next day ending *K* was lost completely; ending *J*, however, survived and grew. By June 6th it had extended and branched near its tip, forming *J1* and *J2*. On June 8th a third branch (*J3*) was present, and *J2* had given rise to two additional short endings. By June 12th, however, *J1* had been eliminated and a reduction in the number of endings of *J2* and *J3* had also taken place. A distance of 0.03 mm is indicated below. (The history of a more proximal portion of this same fiber is given in Fig. 3.)

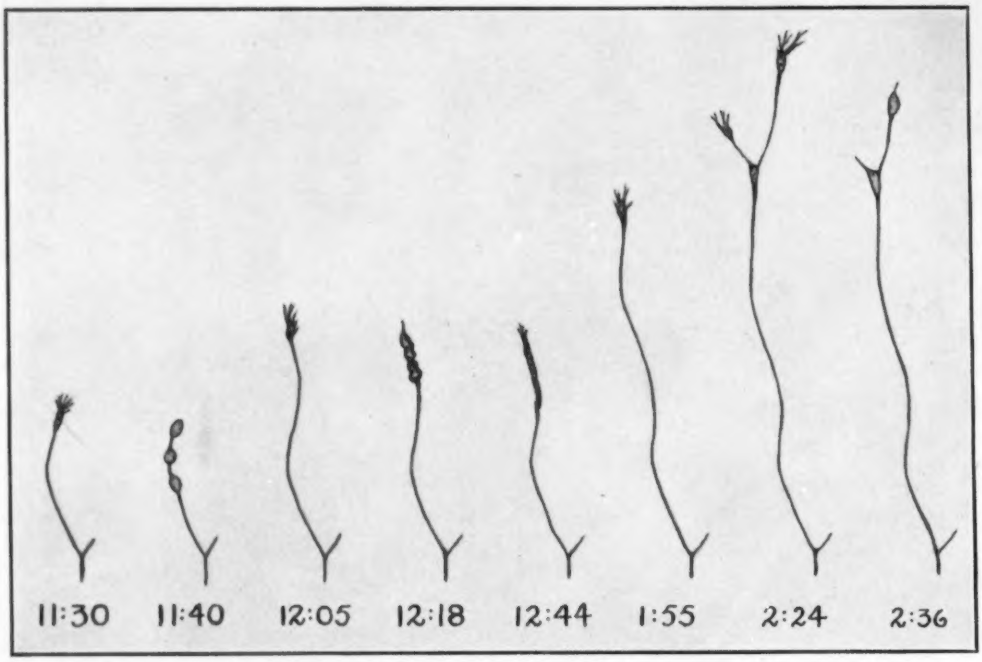

Fig. 5. Successive retraction and extension of a regenerating nerve ending, correlated with alternating periods of electric shock treatment and recovery. Tadpole no. 2422, subjected to electric shocks for a few seconds at 11:37 A.M., 12:08 P.M. (weak), 12:15 P.M., 2:04 P.M. (weak), and 2:33 P.M. The fiber illustrated was growing into the newly regenerating zone four days after removal of the tip of the tail. At 11:30 A.M. the nerve fiber tip was actively advancing. At 11:40 after the first electric treatment the tip became rounded and lost its delicate pseudopods. Two varicosities appeared proximally. Growth, however, was resumed within a few minutes and the tip advanced to the position shown at 12:05. A weak treatment followed by a stronger one caused the formation of a typical retraction club at 12:18. Growth was inhibited for nearly a half hour. At 12:44 the tip is just beginning its transformation back into a growth cone. Further growth took place as illustrated at 1:55 P.M. and 2:24 P.M. A weak electric treatment at 2:04 P.M. failed to stop the advancing growth cone. Extension and branching took place as indicated at 2:24 P.M. A final electric treatment caused retraction of both tips within a few minutes at 2:36 P.M. Recovery and further growth then followed along both branches and by the following day both tips had extended long distances.

example is given (Fig. 8) in which a swollen end bulb underwent autotomy and was taken up at once by a macrophage. At the new nerve tip an abortive growth cone developed, but it soon became transformed into an irritated resting end bulb.

Histories of Nerve Endings in or Near Regenerating Zones

In previous papers (Speidel, '33 and '35) an account has been given of the behavior of the rapidly advancing nerve tips in newly regenerating zones. Therefore, these need not be considered here. In older zones of regeneration some fibers become provided with myelin sheath segments. Terminal arborizations of nerve endings arise at some of the nodes of Ranvier. Such arborizations of endings exhibit growth adjustments as the regenerating zone becomes more mature.

There is no essential difference between the growth adjustments of arborizations of regenerating zones and those of normal zones. In another paper (Speidel, '42) the adjustments of terminal arborizations during normal tadpole growth have been described. The endings in regenerating zones seem somewhat less stable and the arborizations are less complex, *i.e.,* they comprise fewer branches and endings.

One case is presented here (Fig. 9) which shows the main changes over a period of 21 days. Retraction and loss of one ending and the genesis and growth of another take place. At the same time various adjustments of the myelin sheath

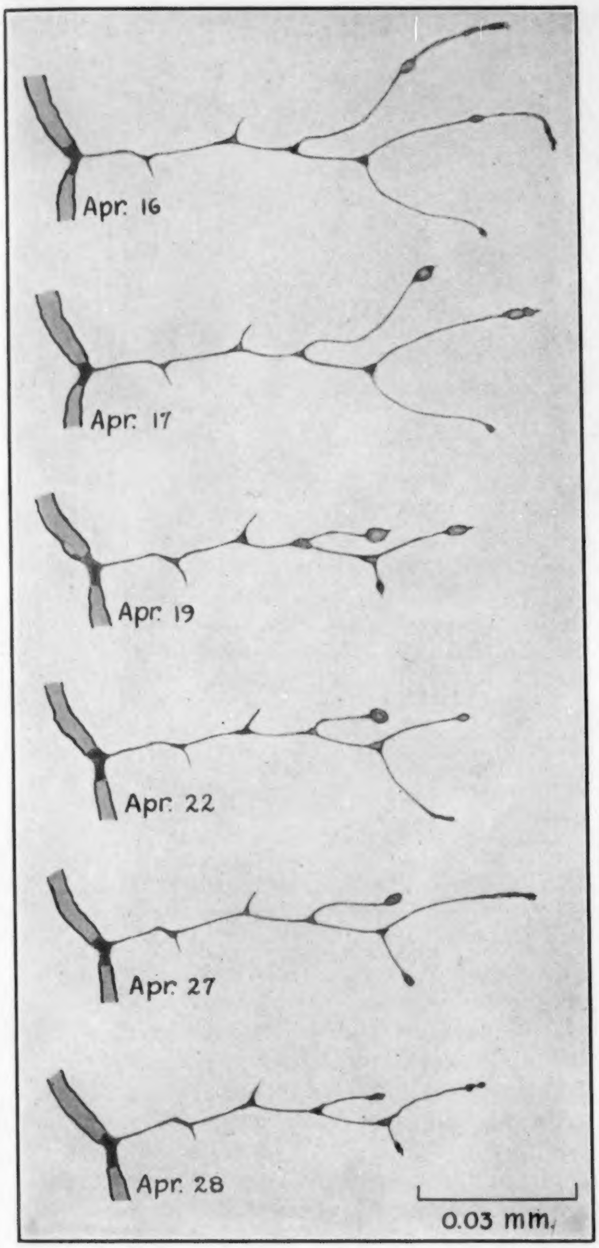

FIG. 6. Retraction and extension of nerve endings correlated with periods of starvation and good nutrition. Tadpole no. 2419, starved from April 16th to 20th and from April 27th to 29th; food available at other times. The sketches are drawn exactly to scale from motion picture records. On April 16th in a young tadpole three endings of a terminal arborization were observed, two of which were advancing. On the following day these two were retracting, their tips being in typical swollen retraction club state. By April 19th marked retraction by all three endings was apparent. By April 22nd after food was available the lower ending had recovered and grown out, and by April 27th the middle ending also had grown. On April 28th after a second starvation period all three endings exhibited some retraction. A distance of 0.03 mm is indicated below. (The history of an ending belonging to the same myelinated fiber located nearer the tip of the tail is given in Fig. 7.)

segments at the base of the terminal arborization occur. Possibly the myelin sheath adjustments are responsible for the elimination of one of the side branches (branch *J*).

Two other endings of the same arborization were also watched, although these have not been included in the sketches. Each of these exhibited limited changes from day to day of both extension and retraction at the tips. The net result, however, was relatively little change in position of the end bulbs.

Nerve endings close to a wound suffer irritation. They may swell and retract slightly. As wound repair proceeds and as the tissues undergo regulation and regeneration, the irritated nerve endings also recover. At times growth and branching take place. The presence of the adjacent regenerating tissues seems to stimulate progressive changes in the nerve endings. This is well illustrated by the example given (Fig. 10).

Histories of Nerve Endings under Various Other Conditions

A few other observations and experiments on nerve endings deserve brief mention. These include nerve ending behavior in tadpoles approaching metamorphosis, and in tadpoles subjected to treatments with chloretone, alcohol, hot water, hypertonic salt solution, and insulin.

As a tadpole approaches the time for metamorphosis, regressive changes take place in the tail. Reduction in size of the tail proceeds and the circulation is markedly affected. Conspicuous structural changes are noticeable in the epithelium, muscle, and nerve. Many endings of terminal arborizations exhibit swelling and slight retraction. These are typical irritative changes that parallel the early degenerative changes in the tail, an appendage that is soon to be resorbed. Occasionally, however, a nerve ending grows while the tail as a whole is being reduced in size. The case illustrated (Fig. 11) shows an advancing ending over a 4-day period just before the tail was lost and metamorphosis completed. In another tadpole a large growth cone was noted in the degenerating tail only 2 days before the animal left the water (Fig. 14). Growth was very slight in this case.

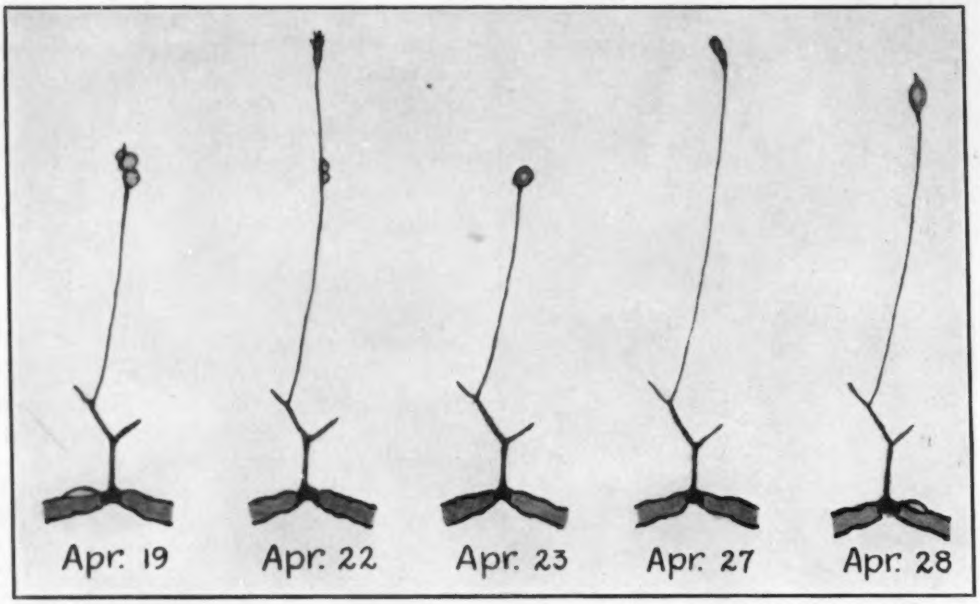

FIG. 7. Retraction and extension of a nerve ending correlated with periods of starvation and good nutrition. Tadpole no. 2419, starved from April 16th to 20th and from April 27th to 29th; food available at other times. The sketches are drawn exactly to scale from motion picture records. On April 19th after three days of starvation a swollen irritated ending was visible, as indicated. After food became available this ending grew out and on April 22nd it was slowly advancing. On April 23rd, though food was still available, it retracted to its former location. By April 27th growth again had taken place. On April 28th after another period of starvation it again exhibited swelling and some retraction. (The history of endings belonging to the same myelinated fiber located farther proximally is given in Fig. 6.)

In a previous paper (Speidel, '36) I have pointed out that the resting endings of terminal arborizations exhibit less conspicuous changes during alcoholic intoxication than do the growing endings of regenerating fibers. Chloretone anesthesia experiments bring out the same difference. One example is cited (Fig. 12) which clearly demonstrates the stability of resting endings throughout alternating periods of deep and light chloretone anesthesia during which a growing ending exhibited alternating extension and retraction.

If a tadpole is immersed in water heated to a temperature of more than 37° C nerve fibers become irritated. An actively advancing growth cone of a regenerating fiber may become transformed into a retraction club. Swollen varicosities may also appear along the irritated fiber. One example is illustrated (Fig. 13). In this case a growing tip retracted slightly after the first heat treatment. It then grew and gave rise to two branches as recovery took place. A second brief heat treatment temporarily stopped the advance of each of the growing tips and caused some swelling. With the restoration of normal conditions reduction of swelling and further growth of the endings occurred within a short time.

I have watched the same kind of changes in growing nerve fibers in tadpoles subjected to suitable irritative treatments with hypertonic sodium chloride solution. Similar changes have also been described with electric shock treatments (*cf.* Fig. 5), with alcohol (Speidel, '36), with metrazol (Speidel, '40), with chloretone (*cf.* Fig. 12), and with insulin (*cf.* Fig. 16).

Nerve fibers usually cease growing in moribund tadpoles. As the blood circulation slows or stops entirely, growth cones round up or become transformed into retraction clubs. Retraction often takes place. Nevertheless, occasionally an actively growing nerve tip is present in a regenerating zone of an animal approaching death even though all other nerve tips exhibit regressive change. The case illustrated (Fig. 15) was observed in a tadpole subjected to severe alcoholic intoxication. Another case practically similar in nature was observed in a tadpole subjected to severe chloretone anesthesia.

Many tadpoles have been subjected to insulin

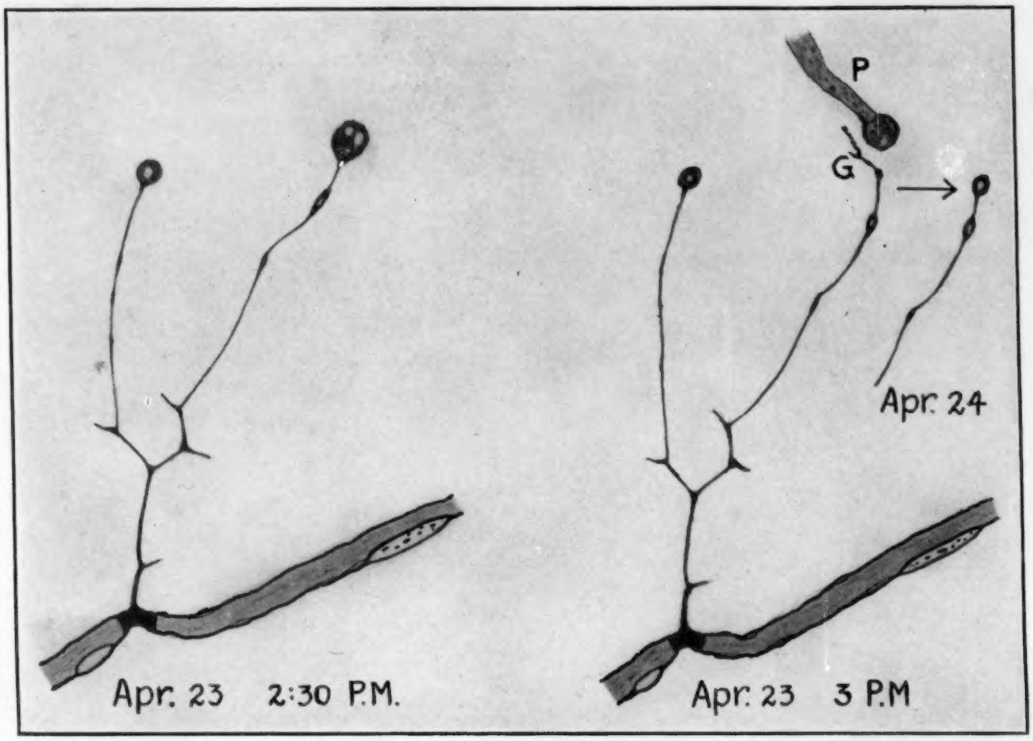

FIG. 8. Autotomy and phagocytosis of the swollen tip of a nerve ending after prolonged starvation. Tadpole no. 1541, regenerating zone following partial tail amputation on March 24th, starved from April 12th on. A motion picture record of this case was obtained. On April 23rd at 2:30 P.M. after eleven days of starvation two swollen tips of nerve endings were observed, branches from an irritated myelinated fiber. One of these during the next half hour suffered autotomy and was ingested by a macrophage, the long process (*P*) of which is figured. A new growth cone (*G*) developed at the tip of the ending and grew slightly at first, but later retracted. On April 24th the tip again was rounded and swollen, as indicated by the arrow.

treatments of various degrees of severity. The insulin extract was not injected; the animals were merely immersed in solutions of suitable strengths. The treatments caused injury to the epithelium and to other tissues. Practically any degree of neuritis could be induced.

Two cases are selected for illustration. The first of these (Fig. 16) shows the advancing growth cone of a regenerating fiber which, with insulin treatment, becomes transformed into a retracting nerve tip. The retraction is temporary. Growth is again resumed soon after normal conditions are restored. The second case (Fig. 17) shows a few highly irritated endings of a myelinated fiber. Each of the three end bulbs pictured is swollen and vacuolated. The parent fiber also displays vacuoles between the myelin sheath and axis cylinder. Nerve fibers in such a condition may recover readily provided the insulin treatment is not continued too long.

Ciné-Photomicrographic Records of Nerve Ending Histories

Besides those already referred to in previous papers, many ciné-photomicrographic records have been obtained of nerve ending adjustments in tadpoles subjected to various injurious treatments. These motion pictures portray cases from tadpoles subjected to electric shocks, insulin, chloretone, starvation, hypertonic salt solution, and wound infliction caused by cutting. Several of the figures of this paper (*e.g.*, Figs. 2, 3, 4, 6, 7, 8, 9, 11, 14, and 17) have been sketched from records of this sort. The subjects of some of the pictures follow:

1. Response of several branches of a terminal arborization to electrical injury. Irritative changes in the endings are shown on the days following a series of electric shocks. Recovery changes during the next two days are also portrayed. Changes in myelin segments during irritation and recovery are also pictured in this case.

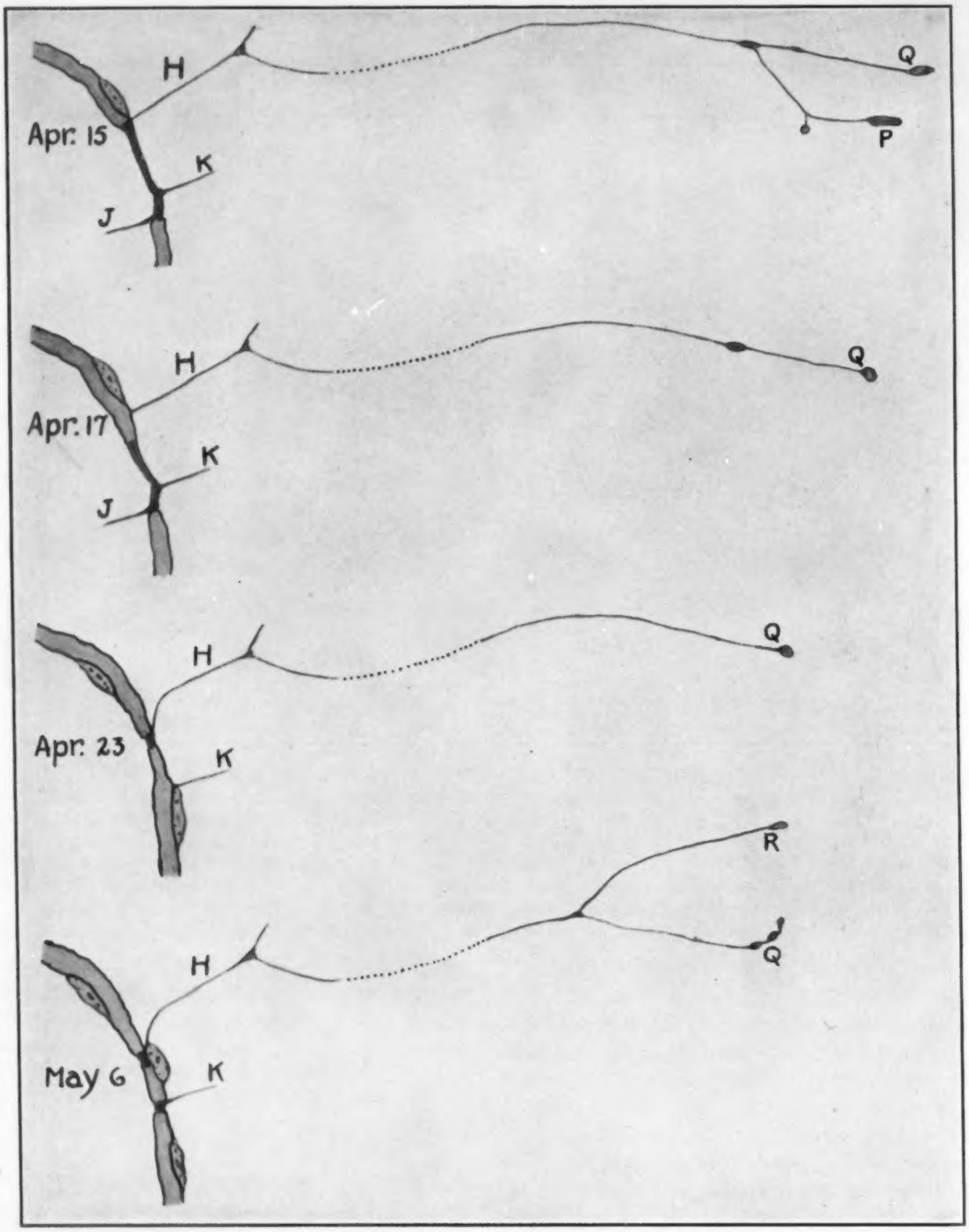

Fig. 9. Nerve ending adjustments during myelination in a regerating zone. Tadpole no. 2417, regenerating zone following partial tail amputation on March 31st. On April 15th after fifteen days of regeneration two endings (*P* and *Q*) were observed which belonged to a collateral (*H*) of a newly myelinated fiber. *J* and *K* represent the bases of two other collateral branches. The myelin segment below *J* was the terminal segment of the fiber. During the next two days ending *P* underwent retraction and on April 17th was completely gone. New myelin was formed extending beyond the base of *H*. During the next six days myelin sheath adjustments occurred. New myelin was formed in such a manner that the base of branch *H* was pushed distally a short distance; branch *J* was eliminated; and the fiber between *H* and *K* became ensheathed with myelin belonging to the lower segment. Ending *Q* retracted a short distance. By May 6th a new branch *R* had made its appearance and grown to the position shown; ending *Q* shifted slightly. The myelin between *H* and *K* together with a new sheath cell formed a new short segment. During the period of observation from April 15th to May 6th four new myelin segments also were formed at the peripheral end of the fiber illustrated. (The dotted line indicates that a part of the length of the fiber has been omitted from the drawing.)

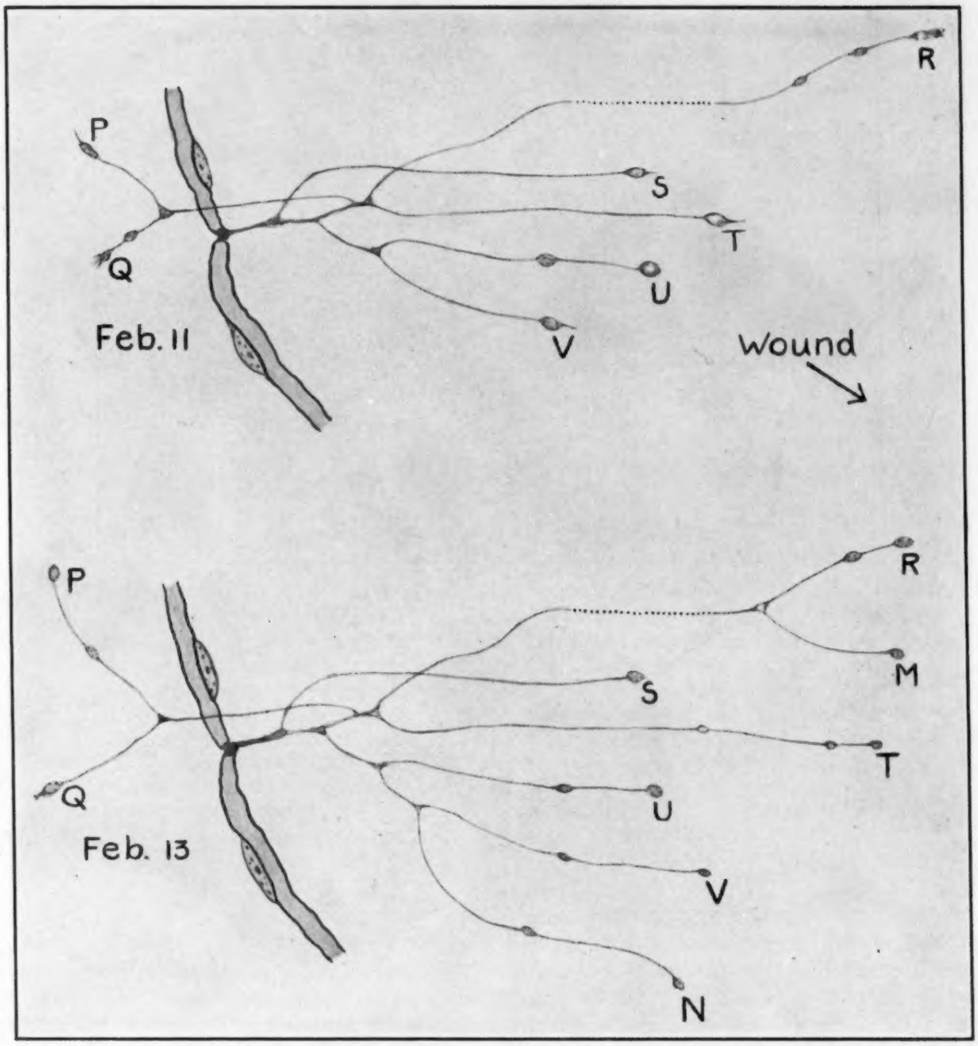

FIG. 10. Recovery of the endings of a terminal arborization located at the proximal edge of a wound. Tadpole no. 1918, ventral fin in the direction of the arrow wounded by cutting on February 9th. The myelinated fiber illustrated was severed by the cut, but the portion figured was on the proximal side of the wound and did not degenerate. During the next two days irritative changes of swelling and retraction were visible in the endings of the terminal arborization, as general tissue regulation took place. On February 11th retraction clubs were present on endings *P, S, T,* and *V*. A swollen tip characterized ending *U*. Ending *Q*, however, was provided with a growth cone that displayed typical ameboid motion. Correlated with wound healing of the next two days, recovery changes were exhibited by the branches of the terminal arborization. On February 13th all endings except *Q* and *S* were of the usual spherical resting type. Endings *P, Q, T,* and *V* had grown some. Two entirely new branches, endings *M* and *N*, had developed in the positions shown. (The dotted line indicates that a part of the length of the branch ending in *R* has been omitted from the drawing.)

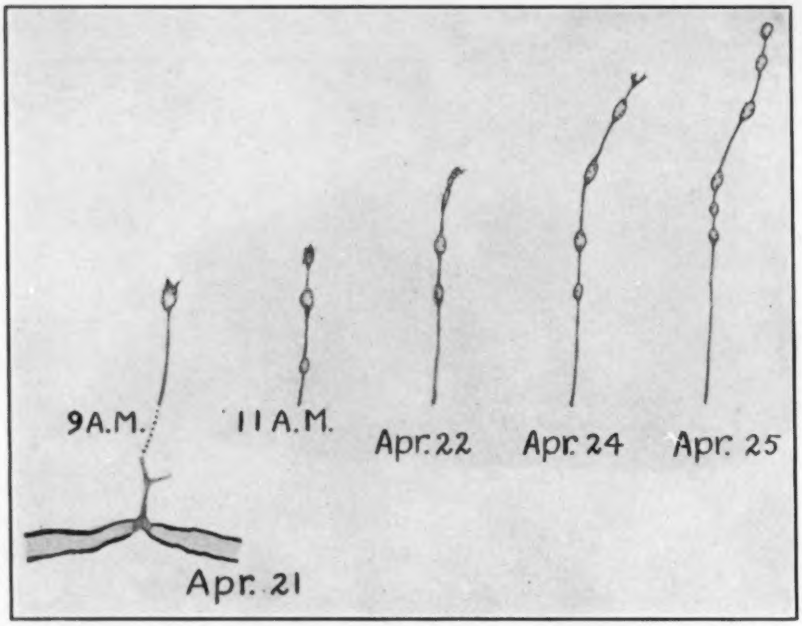

FIG. 11. Growth of a nerve ending in a tadpole nearing the time for metamorphosis. Tadpole no. 2247, with large hind limbs and with its tail beginning to show degeneratve changes. The sketches are made exactly to scale from motion picture records. On April 21st at 9 A.M. a swollen nerve ending was observed. (The dotted line indicates that a part of its length has been omitted from the drawing.) The ending slowly advanced and reached the position shown at 11 A.M. Further advance took place during the next few days, its position being shown on April 22nd, 24th, and 25th. The total advance measured 40 microns. At the same time some reduction in the size of the tail occurred. On April 26th both fore limbs had appeared and the tail was greatly reduced in size. On April 27th the tadpole left the water and metamorphosis was nearly complete.

2. Effects of severe electrical injury on some of the endings and myelin segments of a nerve fiber. Irritative and degenerative changes are recorded for some endings and myelin segments. Growth and branching of a surviving ending are pictured on the 1st, 5th, 7th, 11th, and 13th days after the injury. Complete loss of several myelin segments is shown.

3. Examples of swollen and retracting end bulbs at the tips of arborization branches in a badly injured tadpole on the day following electrical treatment. Death of the animal in this case ensued two days after the injury.

4. Acutely irritated myelin segments during the first few hours after electrical injury. Vacuolation and myelin ovoid formation are illustrated both in tadpoles that recover from the treatment and in those that later succumb.

5. Effects of electric shocks on actively advancing growth cones of regenerating nerve fibers four days after tail section.

6. Effects of electric shocks on epithelium, muscle, blood vessels, blood cells, and pigment.

7. Several examples showing the characteristic irritative effects of starvation on nerve endings and on myelin segments.

8. Several cases illustrating the recovery of irritated nerve endings in tadpoles after periods of starvation from three days to three weeks.

9. Swelling, autotomy, and phagocytosis of an end bulb in a tadpole starved for eleven days. Removal of the end bulb was followed by development at the tip of an abortive growth cone.

10. History of several terminal arborization endings in a regenerating zone 15 to 40 days after tail section. Swelling, retraction, and complete elimination of some endings are illustrated, as well as extension and branching of others.

11. Examples of swelling and retraction of endings of myelinated fibers in tadpoles approaching metamorphosis.

12. Examples of advance of endings in tadpoles approaching metamorphosis which already display noticeable tail reduction.

13. Examples illustrating characteristic regressive changes in nerve fiber endings and myelin segments in tadpoles subjected to suitable treatments with the

following: insulin, methyl alcohol, chloretone, lead acetate, hypertonic sodium chloride solution, and heat.

14. Macrophage taking up a myelin globule from an injured nerve fiber, eight hours after the tadpole was subjected to an insulin treatment.

Comments

It is clear from the preceding case histories that a great deal of adjustment is possible in the peripheral distribution of cutaneous nerve endings in injured tadpoles. The general mechanism of change underlying such adjustments is the same regardless of the type of injury. Regressive change is characterized by swelling of end bulbs, retraction, and degeneration. Degeneration may involve only the most distal portion. Recovery change is characterized by reduction of swelling, extension, and the genesis of new branches. Since the endings are unsheathed, the pattern of an arborization after injury and regeneration is usually not exactly the same as the original pattern.

Furthermore, if free nerve endings at the skin are subject to adjustments of this sort, it follows that free nerve endings located elsewhere in the body may behave in like manner. Within the central nervous system free nerve endings are present in large numbers. They link nerve cells at synapses. Strong irritations might break some synapses by causing retraction or degeneration of some of these endings. With recovery new synaptic connections might be established.

Electric shock and insulin treatments markedly affect cutaneous endings in tadpoles. It seems probable that they profoundly affect synaptic endings in the brain. Such changes in human mental patients under treatment for mental disorders would afford an adequate anatomical basis for the observed changes in mental outlook that sometimes result. This interpretation is like that already advanced after an experimental study of the effects of metrazol on nerve fibers (Speidel, '40).

Summary

1. Case histories are presented of individual nerve endings of terminal arborizations of myelinated fibers in frog tadpoles subjected to various kinds of injurious treatments. Electric shocks, starvation, chloretone anesthesia, wound infliction, insulin, and heat have each been used to induce nerve ending irritation.

2. Swelling, retraction, and variable amounts of degeneration characterize markedly irritated endings. Reduction of swelling, extension, and branching characterize endings in process of recovery.

3. Changes associated with chronic neuritis, such as are induced by starvation, are essentially similar to those associated with acute neuritis, such as are induced by electrical injury.

4. Examples are also presented of the behavior of rapidly growing nerve tips in young regenerating zones, as these are subjected to acute irritative treatments of several kinds.

5. In regenerating zones several weeks old during the later stages of myelination, nerve endings of terminal arborizations exhibit slow adjustments of retraction, extension, and branching. These are quite like similar adjustments that take place in normal zones of young growing tadpoles.

6. It is clear from these observations that nerve ending patterns are not necessarily fixed and stable. The changed conditions imposed by experimental injuries often cause marked adjustments of the endings which result in new patterns. Such adjustments probably also occur at some synapses between nerve cells within the central nervous system.

7. Illustrative ciné-photomicrographs have been obtained.

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Explanation of Plate I

Fig. 12. Absence of visible change in the endings of a terminal arborization during chloretone treatment severe enough to induce retraction of the growth cones of regenerating fibers. Tadpole no. 1706, subjected to strong chloretone treatment from 9:37 A.M. to 9:52 A.M. and from 10:33 A.M. to 10:53 A.M. At other times the tadpole was immersed in either pond water or very weak chloretone solution. At the right of the figure is illustrated the growing ending of a nerve fiber in the rapidly regenerating tail tip zone, four days after tail section. At the left of the figure is illustrated the resting endings of a terminal arborization in the normal unoperated tail zone. The regenerating ending exhibited typical retraction during the strong chloretone treatments, as shown at 9:49 A.M. and 10:45 A.M. At other times this ending was provided with a growth cone which slowly advanced. The terminal arborization endings, on the other hand, exhibited practically no change throughout the treatments (except perhaps very slight vacuolation).

Fig. 13. Retraction and recovery of a regenerating ending correlated with heat treatments. Tadpole no. 1551, regenerating zone four days after tail section, immersed in hot water (40°–41° C) for brief periods of less than one minute at 10:15 A.M. and at 11:51 A.M. The advancing tip of a regenerating nerve fiber was observed at 10:05. Swelling and some retraction took place after hot water treatment, as shown at 10:20. During the next ninety minutes growth was resumed and the ending branched into two, as shown at 11:50. A second treatment with hot water again caused some retraction and the formation of swollen varicosities, as shown at 11:55. Ten minutes later at 12:05 both endings exhibited recovery and were again advancing.

Fig. 14. Advance of a nerve ending in a metamorphosing tadpole. Tadpole no. 2409, tail markedly reduced in size, all four limbs visible. On May 5th in a tadpole which exhibited pronounced degenerative changes in the tail a nerve ending provided with a blunt growth cone was observed. On May 6th this had advanced a short distance in spite of the fact that the tail was undergoing rapid involution. On May 7th the animal left the water, tail resorption being far advanced.

Fig. 15. Advance of a regenerating nerve ending in a moribund alcohol-treated tadpole after cessation of the blood circulation. Tadpole no. 1514, regenerating zone four days old, immersed in 2 per cent alcohol from 11:23 A.M. to 1:15 P.M. At 12:43 an active growth cone was noticed at the tip of a fiber. All other regenerating tips of nerve fibers in the vicinity were in various stages of retraction. (One that was kept under observation retracted 25 micra between 11:44 and 12:42.) The growth cone illustrated, however, rapidly advanced during the next half hour reaching the position shown at 1:13, an advance of about 30 micra. Blood circulation in the tail ceased at 12:25 and was not resumed thereafter.

Fig. 16. Retraction of the tip of a regenerating nerve fiber in an insulin-treated tadpole, followed by growth of the nerve tip during recovery. Tadpole no. 2429, regenerating zone four days old, immersed in insulin solution from 9:26 A.M. to 10:10 A.M. An advancing growth cone at the tip of a regenerating fiber at 9:15 was transformed during insulin treatment into a retracting tip, as shown at 9:55. After replacement of the tadpole in pond water for about twenty minutes the nerve fiber tip resumed its advance, reaching the position shown at 11:15. Although the treatment injured the epithelium somewhat the tadpole survived without difficulty.

Fig. 17. Irritative changes in the endings of a myelinated fiber in an insulin-treated tadpole. Tadpole no. 2412, immersed in strong insulin solution for twelve minutes. A motion picture record of this case was obtained. One hour after the treatment, each of the three end bulbs shown in the illustration exhibited swelling with a centrally located vacuole. Two of the endings terminated in a short pointed filament. Vacuoles were also conspicuous in several places along the myelin segment where separation of the axis cylinder and myelin sheath had taken place.

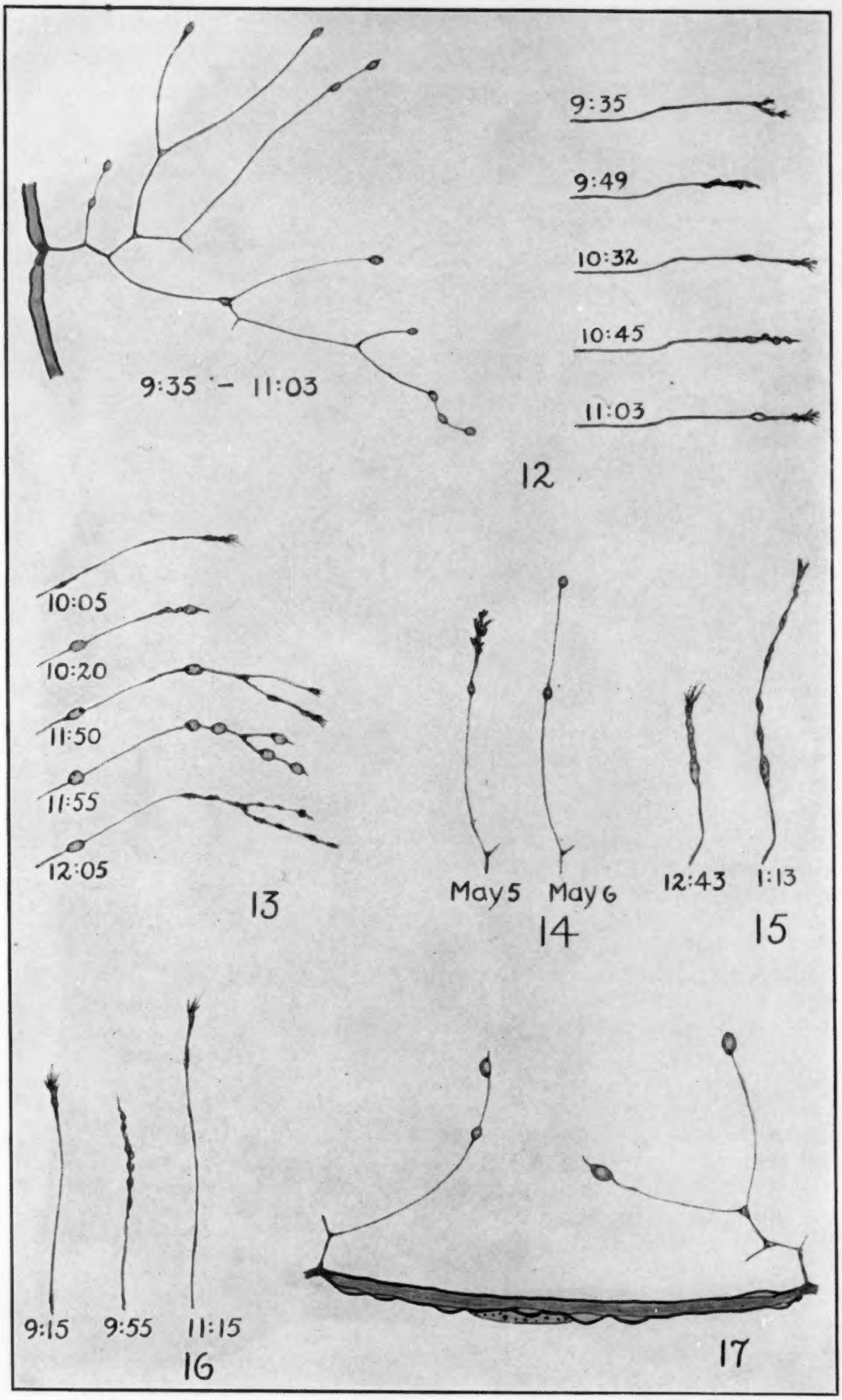
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PLATE I

NEW MUTATIONAL SEGREGATIONS FROM *OENOTHERA* MUT. *ERYTHRINA* DE VRIES [1]

GEORGE HARRISON SHULL

Princeton University, Princeton, N. J.

CONTENTS

ABSTRACT *

New mutational segregations from Oenothera mut. Erythrina de Vries: GEORGE H. SHULL. *Oe.* mut. *erythrina* de Vries, when selfed, is known to produce in every progeny two types, one repeating the parent, the other a new type, seg. *decipiens,* which breeds true when selfed because it lacks both of the balanced lethals which characterize *Oe. Lamarckiana. Erythrina* splits in this way because it has only one of the *Lamarckiana* lethals. Some years ago I reported the occurrence of a new mutational segregation in which mut. *pollicata* was found to characterize the *decipiens* component of such a splitting progeny, while normal hypanthium, styles and stigmas characterized the *erythrina* component. A continuation of studies with *erythrina* have brought to light a number of new segregations, sometimes replacing *decipiens,* in other cases being additional to *decipiens.* The first of these new mutational segregates was discovered on March 8, 1935, when family 3485, produced from a self-fertilized *erythrina* mother, was observed to split out 45 plants of a peculiar new type afterwards called seg. *petiolaris,* in a total progeny of 164. A complete analysis of this family showed it to consist of 70 *erythrina,* like the parent, 50 seg. *decipiens,* 43 seg. *petiolaris,* and 1 unidentified mutant. Over half of the *erythrina* plants in such a family repeat the three-way split when selfed, while the rest split only to *erythrina* and *decipiens.* On March 20, 1938, another remarkable new segregation, seg. *contracta,* was discovered in family 37428, derived from an *erythrina* mother in this same strain. The unique feature this time was not alone the remarkable modification represented by the new type itself, but seg. *contracta* replaces seg. *decipiens.* Family 37428 consisted of 61 *erythrina* and 40 *contracta,* no *decipiens* being present. Every *erythrina* plant in such a family produced the same kind of a family, consisting of *erythrina* and *contracta.* In 1939 another new segregate, seg. *diminua,* was found, and in 1940, still another, seg. *cyanea,* was added to a *contracta*-segregating family (39533) which split to 61 *erythrina,* 25 *contracta,* 16 *cyanea.* In 1941 one family (40110) from selfed *erythrina* has had the *decipiens* segregate replaced by seg. *elongata* and in another progeny (40130) seg. *retracta* has replaced seg. *contracta.* An essentially true-breeding *erythrina* has resulted when seg. *decipiens* is replaced by seg. *sublethalis,* the latter being rarely seen because it has so little chlorophyll that usually it does not live beyond the germination stage. This "non-splitting" *erythrina* was discovered in 1938 in family 37411, but seg. *sublethalis* was not observed until the current year (1941).

INTRODUCTION

IT is now well known that the mutations discovered in the Oenotheras by Hugo de Vries and subsequent workers are of several different kinds, including gene mutations as well as several different sorts of chromosomal aberrations. Several of these chromosomal irregularities result in characteristic changes in chromosome numbers, such as trisomics with 15 chromosomes, triploids with 21, tetraploids with 28, instead of the 14 which are normally present in *Oe. Lamarckiana* and in all of the known wild species of Oenothera.

The present paper deals with the genetical behavior of a mutant which is produced by a chromosomal aberration of a different kind, which affects the *arrangement* of the chromosomes without changing their number. There are four well-known mutants of this character, beginning with *Oe.* mut. *rubrinervis,* followed by *Oe.* mut. *erythrina, Oe.* mut. *rubricalyx* and *Oe.* mut. *rubricalyx* "Afterglow." These differ from *Oe. Lamarckiana,* from which they have been derived, in two very fundamental particulars, namely, (1) a reduction of the circle of 12 chromosomes of *Lamarckiana* to a circle of 6 or a circle of 8, the remaining chromosomes required to make up the typical 14 occurring in separate pairs, 3 pairs if the circle includes 8 chromosomes, or 4 pairs if

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the circle consists of 6 chromosomes; and (2) a loss of one of the balanced zygote lethals which give *Lamarckiana* the remarkable ability to breed true, notwithstanding the fact that every plant of *Lamarckiana* is a heterozygote.

This loss of one lethal factor makes possible the appearance of a homozygous segregate as a feature of the progenies of every self-fertilized plant of one of these mutants. The remaining lethal keeps *rubrinervis, erythrina, rubricalyx* and *rubricalyx* "Afterglow" just as permanently heterozygous as *Lamarckiana* itself, but instead of breeding true, *Oe.* mut. *rubrinervis* produces a progeny consisting of *rubrinervis* and *deserens; erythrina,* a progeny containing *erythrina* and *decipiens;* and *rubricalyx* and *rubricalyx* "Afterglow" give progenies consisting of *rubricalyx* and *latifrons.* The theoretical expectation in each of these four cases involves a 2:1 ratio, which, however, is almost never closely approximated in actual experience. This general failure to yield a 2:1 ratio shows that other factors are also involved, including perhaps inequality in the successful formation of the different kinds of gametes, selective fertilization, and differential survival value of the zygotes.

These four mutations with characteristically splitting progenies are known as "half-mutants," a term originally used by de Vries (1918) with a somewhat broader significance, as he applied it to the result of the union of any newly mutated gamete with an unmutated gamete of the parent type, and assumed that this phenomenon is of necessity involved in the origin of almost every mutant type. More properly the four mutant types here under consideration might be designated *permanent half-mutants,* since most of the mutants to which de Vries applied the concept of "half-mutants" change their status in time from half-mutants to full mutants, while these four maintain their "half-mutant" condition permanently, owing to action of the one remaining lethal factor.

The present paper deals only with *Oenothera* mut. *erythrina,* presents two new kinds of genetical behavior, and describes seven striking new mutational segregations which have appeared within the past six years in my cultures of *Oe.* mut. *erythrina.*

Historical

None of the four permanent half-mutants now known was recognized as a half-mutant at the time of its first discovery. The *Oe.* mut. *rubrinervis* has been from the beginning of the experimental cultures of Oenothera one of the easiest to recognize. According to de Vries's account it was first observed by him in 1889 as an aberrant offspring in a culture of self-fertilized *Oe.* mut. *laevifolia.* As a derivative directly from *Lamarckiana* it first appeared as a single individual in 1890–91 in cultures comprising somewhat more than 10,000 plants of *Oe. Lamarckiana,* and during the next three years he found 31 *rubrinervis* plants among 23,800 plants of *Lamarckiana* and 733 other recognized mutants tabulated under the names, *gigas, albida, oblonga, nanella, lata* and *scintillans.* He first began to study the breeding behavior of *Oe.* mut. *rubrinervis* in 1895 and grew somewhat over 1000 offspring from selfed *rubrinervis* in each of several succeeding years. He overlooked the regularly recurring segregate, *Oe.* seg. *deserens,* and concluded that *Oe.* mut. *rubrinervis* was a fully constant elementary species. The first account of these studies was published in 1901 in *Die Mutationstheorie,* Vol. 1, pp. 155–163. Not until 1913 did de Vries note that *rubrinervis* regularly yields a progeny consisting of *rubrinervis* and seg. *deserens* (de Vries 1917).

The history of *Oe.* mut. *erythrina* is as follows. In 1905, at my request, Doctor de Vries sent me ten large rosettes of *Oenothera Lamarckiana,* collected in the same abandoned potato field near Hilversum, Holland, from which his original material of this species had been taken in 1886. These rosettes were received at the Carnegie Institution's Station for Experimental Evolution on April 7, 1905. In my culture 0557, produced by crossing two of these plants received from de Vries, one plant in a family of 77 was probably the first *Oe.* mut. *erythrina* ever seen by human eyes. It was noted in August 1906, when it was recorded as *"rubrinervis."* Several new specimens of the same type were observed the following year, and many have been noted in the *Lamarckiana* cultures derived from these ten wild rosettes during all the years which have since unrolled. They were always recorded as *rubrinervis* although it was soon noticed that they were in disagreement with de Vries's description of *rubrinervis* with respect to the brittleness of the branches. It is certain that the specimens noted in 1906 and subsequently were mut. *erythrina,* because the strain of *Oe. Lamarckiana* which originated from this new collection of wild rosettes has since been found to produce repeatedly and consistently only the tough-stemmed *Oe.* mut. *erythrina,* and has never been known to produce the brittle-stemmed mut. *rubrinervis*. According to the statement of de Vries (1919), made when *erythrina* was first named and described, he found his first two specimens of this mutant in the summer of 1907 in the second generation of cultures from a large rosette which he set into his own garden at the same time that he shipped the above-mentioned ten rosettes to me.

From my first specimen of *Oe.* mut. *erythrina*, found in 1906, and from many new mutants of the same type which occurred in subsequent years from my cross-bred strain of *Lamarckiana* based on the 1905 shipment of rosettes, I have grown, over a period of three decades and more, hundreds of cultures from both self-fertilized and from cross-fertilized *erythrina* parents for comparison with the original strain of de Vries's *Oe.* mut. *rubrinervis* seeds of which had been received from de Vries on March 10, 1905. I continued this original *Oe.* mut. *rubrinervis* in my experimental cultures by repeated self-fertilizations while my *erythrina* cultures were being handled mainly as a cross-bred strain. When my cultures of *erythrina* were found to have tough stems while the de Vries strain of *Oe.* mut. *rubrinervis* had brittle stems, I naturally assumed that this difference was one of the effects of self-fertilization, as such, and I used as a descriptive differentiation the terms "selfed type" and "crossed type" of *rubrinervis* to indicate this difference in the toughness of the branches, not realizing that I was comparing two genotypically distinct types which owed their difference to their having originated as "parallel mutations" from two different strains of *Oe. Lamarckiana*, and that the latter were likewise genotypically differentiated in this ability to produce brittle-stemmed *versus* tough-stemmed half-mutants.

The two permanent half-mutants bearing the names *rubricalyx* and *rubricalyx* "Afterglow," were derived from *Oe.* mut. *rubrinervis* and never directly from *Oe. Lamarckiana*, in the cultures of R. R. Gates. The deep-red hypanthia resulted from a dominant gene-mutation which was discovered at Woods Hole, Massachusetts, in the summer of 1907, in an unguarded culture grown from mixed seeds from four specimens of *Oe.* mut. *rubrinervis*. The most notable difference between *Oe.* mut. *rubricalyx* and *Oe.* mut *rubricalyx* "Afterglow," is the fact that the former has a circle of 6 chromosomes and 4 pairs, whereas the latter has a circle of 8 and only 3 pairs.

On the basis of Belling's (1927) brilliant observations and conclusions regarding chromosome circles in Datura, Darlington (1929), Cleland and Blakeslee (1930, 1931) and Cleland (1932, 1933) have plausibly explained the formation of circles of chromosomes in the Oenotheras as the result of segmental interchanges, that is, the exchange of ends by two non-homologous chromosomes. Darlington (1929, appendix) and Cleland and Blakeslee (1931) have shown how the permanent half-mutants, with circles of 6 or 8, may likewise be derived by segmental interchanges in a form like *Oe. Lamarckiana* which has a circle of 12 chromosomes and a pair. Cleland (1931) has shown that the circle of 8 of *Oe.* mut. *rubricalyx* "Afterglow" can be very simply derived from the circle of 6 of its parent *Oe. rubricalyx* Gates by the occurrence of a single additional segmental interchange and has also recently made a very thorough analysis of the different ways in which the half-mutant *erythrina* could be derived from *Oe. Lamarckiana* by a minimum of two coincident or successive segmental interchanges (Cleland 1942).

The Normal Progeny of *Oe.* mut *erythrina*

The recognition of the homozygous seg. *decipiens* as a regular and normal component of progenies of self-fertilized *erythrina* parents, was not clearly attained until the appearance of de Vries's (1919) paper in which the name *decipiens* was proposed, but the range of variation in each such progeny, to include both *erythrina* and *decipiens*, was noted very early, and such expressions as "dark *rubrinervis*" and "light *rubrinervis*" are found in my notes. But the dark (*decipiens*) and light (*erythrina*) variations were considered as merely the fluctuational extremes of a uniform biotype. Figure 1 shows a record of these extremes in a photographic plate made in 1910.

When *Oe.* mut. *erythrina* was finally understood to be a half-mutant, a meticulous effort was made to separate each progeny into its two components (*a*) mut. *erythrina*, the half-mutant parent type, and (*b*) the extracted homozygous seg. *decipiens*. It has been found that under favorable conditions this separation can be accomplished with a fair degree of success; but the conditions have rarely been so ideal that the grouping could be made with complete assurance of accuracy, and there has been usually a small amount of error in the classification, especially in the young rosettes.

From this it will be clear that the features which distinguish seg. *decipiens* from mut. *erythrina* are

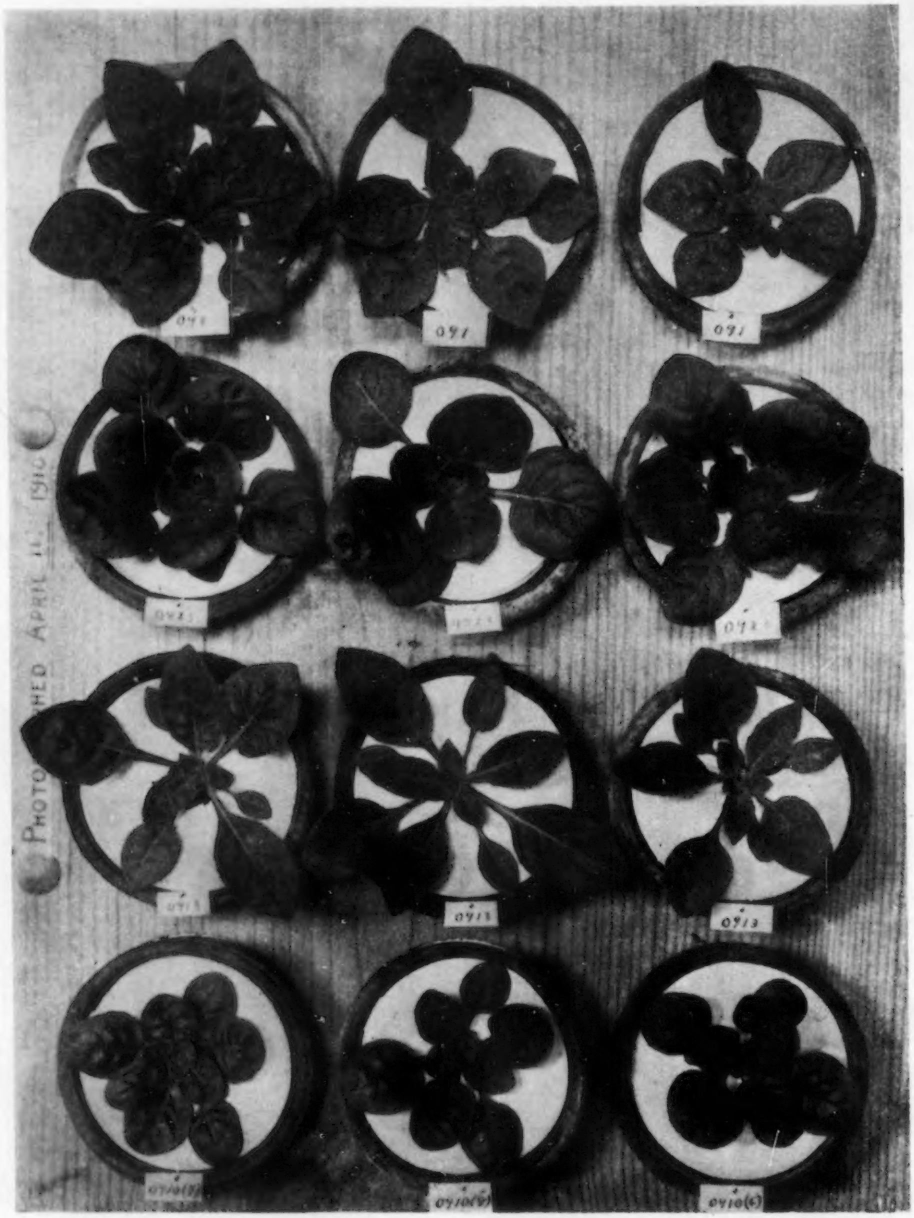

FIG. 1. Young rosettes of *Oe. Lamarckiana* (top row) and three of its chromosomal mutations, *gigas, erythrina* and *lata*. In this old photograph, taken by the writer on April 11, 1910, is shown very clearly the distinction between seg. *decipiens* (at left) and mut. *erythrina* nine years before seg. *decipiens* was reported by de Vries (1919) as a regularly recurring segregate.

neither sharp nor very conspicuous. As young rosettes which have grown well separated and under good environmental conditions seg. *decipiens* has slightly stiffer, darker green leaves with more noticeable and sharper denticulations on the margins of the younger leaves. Often the leaves are slightly crinkled, relatively a little wider and a little sharper at the apex than in mut. *erythrina*. Seg. *decipiens* is usually of slower growth and maturity, its stems are usually rather irregularly crooked, the upper stem leaves likely to be again rather sharply denticulate, but this latter is likewise too variable to have much value as a diagnostic character. The bud-cones have less red pigment than in *erythrina,* and the pigmentation is less evenly distributed.

As a breeder seg. *decipiens* is greatly inferior to mut. *erythrina.* It is slower in development, and often fails to mature as an annual, while mut. *erythrina* is one of the surest of annuals when the seeds are sown in the greenhouse in mid-winter. Seg. *decipiens* and the homozygous segregates from the other half-mutants usually have scanty pollen, and produce a much smaller quantity of seed than the corresponding half-mutants. The best explanation of this marked difference between the heterozygous half-mutants and their homozygous segregates appears to be that the advantages in favor of the half-mutants is a striking illustration of the effect of heterosis, and the conclusion seems justified that the peculiar chromosomal behavior in the Oenotheras has been favored by natural selection of the strikingly more vigorous and more prolific heterozygotes.

Oenothera MUT. *pollicata* AS A RECURRENT SEGREGATE FROM MUT. *erythrina*

I have reported in a previous paper (Shull, 1937) that the remarkable new mutant type mut. *pollicata* characterized among other things by the interpolation of a solid portion of hypanthium between the distal end of the ovary and the proximal end of the style, was the first characteristic which has been found to affect the entire group of *decipiens* segregates while leaving the *erythrina* component of that same family unaffected. The full importance of this case was not at first recognized because the first examples of *Oe.* mut. *pollicata* were found as mutations from *Lamarckiana,* and most of my experiments with *pollicata* involved only such as were associated with both of the *Lamarckiana* lethals. Not until 1934 was *pollicata* found associated with *erythrina* and as reported (Shull, 1937) there were in that year, three families each derived from a self-fertilized *erythrina,* in which all of the 117 *decipiens* plants which bloomed were *decipiens pollicata,* while all but one of the *erythrina* plants (286:1) in the same families were non-*pollicata.* This apparent replacement of *decipiens* with *decipiens pollicata* excited interest at the time only as giving additional proof that the *pollicata* gene is in the first linkage group where it is associated, in *Lamarckiana,* with the balanced lethals l_1, l_2, and in *erythrina* with only one of these, either l_1 or l_2.

Sensing the possibility that I might have overlooked previous occurrences of *pollicata* when associated with *decipiens,* because of the late and poor development of the *decipiens* component of each *erythrina* progeny, I sowed in 1935 a new lot of seeds of the original *erythrina* mutant which appeared in 1930 in *Lamarckiana* family 2930. This new family from the old seed bore the number 34212 and duplicated family 30231 in which latter I would have had my first opportunity to overlook the *pollicata* character if it were actually present in 1931 in the *decipiens* component of a family ancestral to those families which in 1934 were found to contain seg. *decipiens pollicata.* Family 30231 had had 97 or 98 *decipiens* and 89 or 88 *erythrina;* 55 of the *decipiens* plants bloomed, but were not recognized as *pollicata.* However, when special attention was given to this point in family 34212, grown from the same seed in 1935, it was found that the family consisted of 59 *decipiens* and 66 *erythrina* and that 46 *decipiens* (all that bloomed) were *decipiens pollicata,* while the 59 *erythrina* plants which bloomed were all normal-styled, *i.e.,* non-*pollicata.* This shows that seg. *decipiens pollicata* was present but unrecognized in my cultures in 1931, a year before mut. *pollicata* was first doubtfully discovered in 1932 in a *Lamarckiana* family and three years before it was actually recognized as a segregated component of an *erythrina* family.

The replacement of the entire group of *decipiens* plants in these families by *decipiens pollicata* presents no difficulty of interpretation, since the characteristic vegetative peculiarities of seg. *decipiens* are not notably changed by the presence of the *pollicata* gene. One needs only to think of the gene for tubular hypanthium and normal long stiff style being replaced by its mutational allele, the *pollicata* gene. But the other new types which have replaced seg. *decipiens,* or which have been added to the *decipiens* segregate in families from selfed *erythrina,* as presented below, do not suggest such a simple interpretation for them.

Oenothera seg. *petiolaris,* seg. nov.

The first and one of the most remarkable new mutational segregates I have found was discovered March 8, 1935, when family 3485 was potted from the seedpan to 75 mm pots. It could have been observed much sooner for we have found since that seg. *petiolaris* becomes sharply distinguishable from both *erythrina* and seg. *decipiens* in a very early seedling stage. Figure 2 shows a por-

FIG. 2. Seedpan 37457 with seedlings from a self-fertilized *Oe.* mut. *erythrina,* showing segregation of seg. *decipiens* and the first of the new segregations, seg *petiolaris.* Photo April 1, 1938.

tion of a seedpan containing mut. *erythrina,* seg. *decipiens* and seg. *petiolaris.* The contrast becomes greater as the plants continue to grow. Every feature of the *petiolaris* plants is in striking contrast with the corresponding feature of the parent *erythrina.* The full grown rosette is gray green, very coriaceous, and the leaves consist of very long petioles, and the very small blades are asymmetrical and variously and irregularly lobed, as shown in Fig. 3. Seg. *petiolaris* is a fairly hardy type and withstands field conditions well, but it is of relatively slow growth, as might be

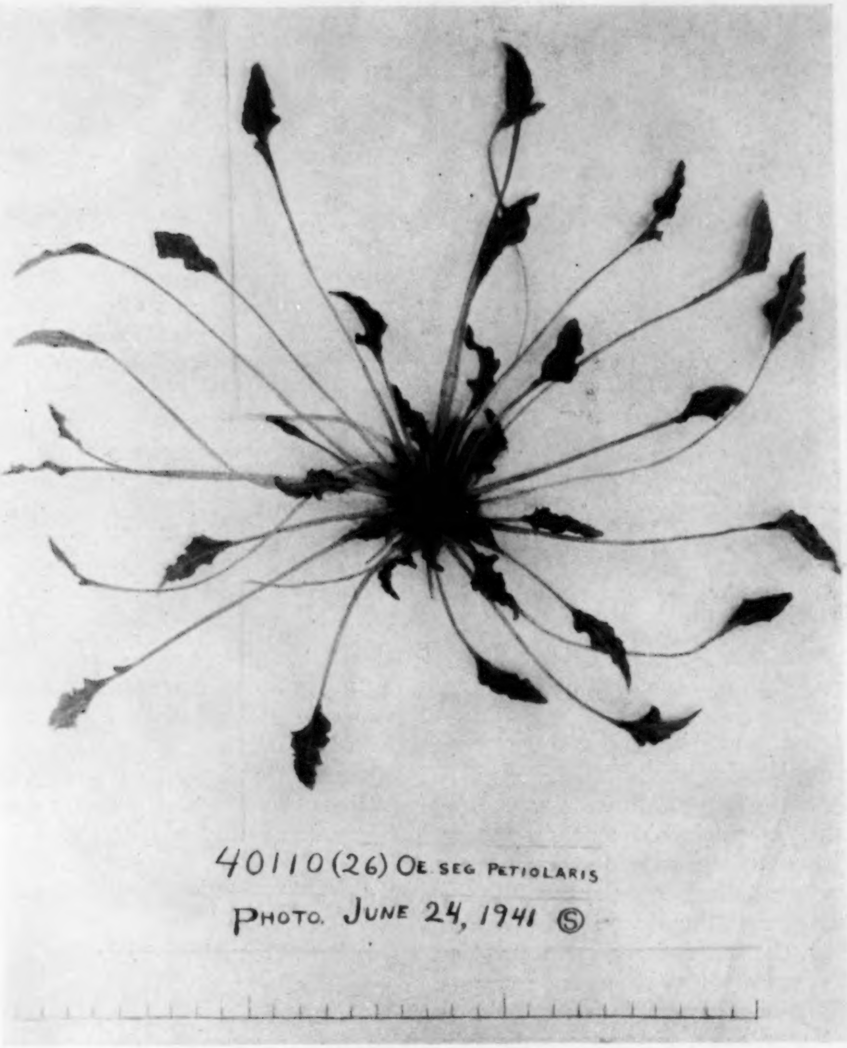

FIG. 3. Rosette of *Oe.* seg. *petiolaris* six weeks after being set in the experimental field. The smallest segments of the scale below are centimeters.

anticipated because of the small volume of the green tissues.

Under most favorable field conditions a few of the plants produce stems well branched, the branches notably straighter than in *decipiens* and more erect than in *erythrina* (cf. Figs. 4 and 5). More commonly no basal branches develop, but very numerous short branches develop on the central axis. The stem leaves are very numerous, narrow, with upturned nearly entire margins and much shorter petioles than in the rosette leaves, but still much longer than in *erythrina* stem leaves. The petioles of the stem leaves of seg. *petiolaris* are one-third to one-half as long as the blades (see Fig. 29). A very few *petiolaris* plants have come to bloom in the field, but rarely early enough to be successfully used in breeding. In this first family (3485) which contained seg. *petiolaris* only one of the 43 *petiolaris* plants matured early enough to be bred. Numerous flower buds began forming on this most precocious *petiolaris* plant about the end of July, but for a long time these buds were regularly dropped long before they reached full development. Not until the end of August were some buds retained until they reached the flowering stage. The buds and the petals of seg. *petiolaris* are notably unlike any I have seen in any other type of Oenothera. The calyx con-

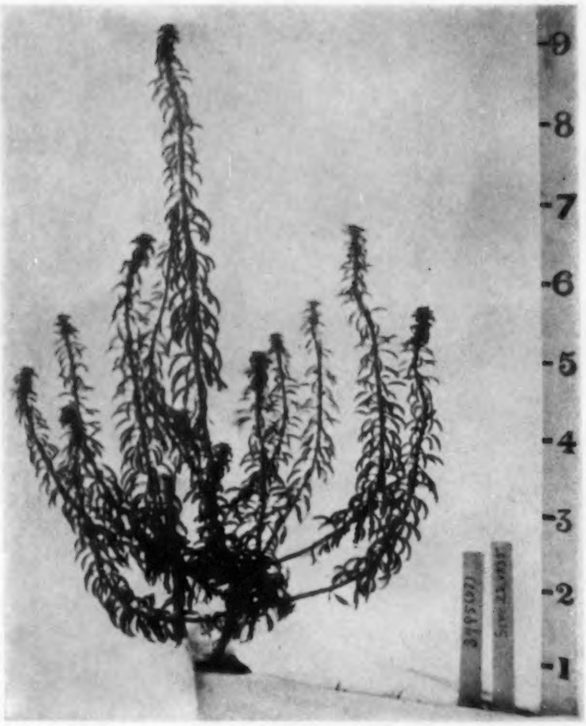

Fig. 4. *Oenothera* seg. *petiolaris*, showing characteristic stem-leaves and a rather unusual branching habit.

sists of narrow sepals which cohere persistently at their tips, but begin to separate from each other in the mid-region of the bud-cones even while the buds are extremely small, thus forming a 4-barred cage within which the other floral parts develop. Sometimes the pressure of these interior organs of the flower succeed in separating one or two or even all four of the sepals, but quite commonly the petals and some of the stamens protrude between the bars of the cage formed by the permanent apical coherence of the sepals (Figs. 6 and 8). These sepals are strap-shaped proximally, but distally the edges are inrolled and occasionally grip an anther securely in this convolute portion, and hold it even when the sepal has been separated at the tip from its fellows. The petals are narrow, especially in their proximal half or more, where they are rendered stiff by a backward (downward) fold along their median line (Figs. 6–8). The cross-section of this proximal portion of the petal has the form of an inverted V or the printer's caret. Distally the petal is broadened and spreads laterally and is irregular in distal outline, corresponding in some degree with the irregular outline of the leaf blades.

The anthers are well developed but usually almost or quite devoid of pollen. I did find good pollen in several anthers of this first sexually matured specimen of seg. *petiolaris* and succeeded in getting a few good capsules from controlled pollinations. The hypanthia of seg. *petiolaris* are relatively long, hollow throughout, and traversed by the rather heavy style which is rendered crooked distally by its imprisonment within the cage formed by the cohering sepals. The stigmas were heavy, clumsy and somewhat irregular.

In 1936 I grew one family (35240) of 41 plants from self-fertilized seg. *petiolaris*. Of these 41 plants, one was *decipiens*, and one a modified *petiolaris* which had no clear-cut blades, but consisted of petioles merely slightly expanded distally. All the rest were like their self-fertilized parent, typical seg. *petiolaris*, as above described, but none of these bloomed early enough to be used for a continuation of the experiment.

Another family (35241) consisting of 37 plants resulted from the pollination of seg. *petiolaris* with pollen of a seg. *decipiens* sib. When making this cross I was entertaining the working hypothesis that the *petiolaris* would be found to bear the same relation to the *velans* complex and its lethal, l_2, that *decipiens* seemed to have to the *gaudens* complex and its accompanying lethal, l_1, a hypothesis that has not been substantiated by

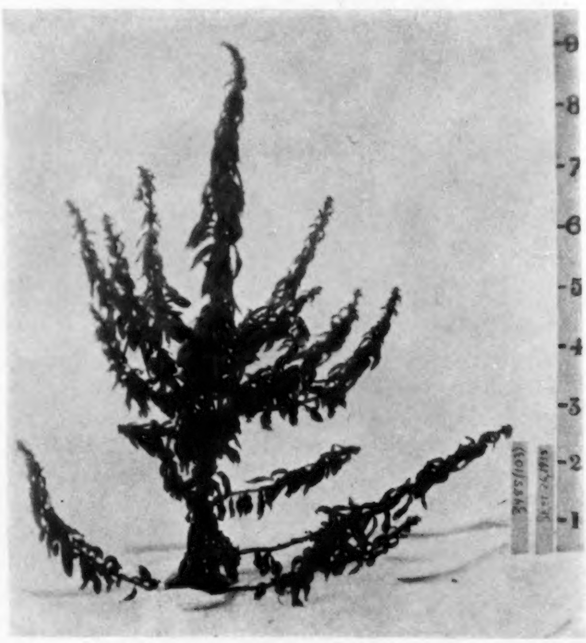

Fig. 5. Habit of *Oe.* mut. *erythrina*, for comparison with Fig. 4.

FIG. 6. A single opening flower of *Oe.* seg. *petiolaris* showing the petals escaping from the frame-work formed by the terminally cohering sepals. Photo in 1936 by W. H. Brittingham.

subsequent results. On this hypothesis it was anticipated that *petiolaris* × *decipiens* might give a family of uniform *erythrina*, which could be expected subsequently to split regularly to *decipiens*, *erythrina* and *petiolaris* in about a 1:2:1 ratio. The 37 plants of family 35241 consisted of 17 *decipiens* and 20 probably *erythrina* of which latter 6 were smaller and slightly darker green, but believed to be *erythrina*, nevertheless.

The seg. *decipiens* plant used in the cross with seg. *petiolaris* was also selfed, and the progeny from this selfing was grown in 1936 as family 35242. This consisted of 152 plants of which 35 died in the pots after they were set from the seedpan. One plant was divergent from the rest, having narrower leaves with declining margins. All of the remaining 116 plants were seg. *decipiens*. In the experimental field 48 of these died, 23 failed to bloom, mostly remaining winter rosettes, and 54 which bloomed were all *decipiens pollicata*.

In the same family (3485) which contained the first plants of seg. *petiolaris*, I also self-pollinated five specimens of *Oe.* mut. *erythrina*, expecting in this way to insure the continuation of seg. *petiolaris* even though the meager results from the direct breeding with *petiolaris* itself should prove disappointing. The resulting families, 35243 to 35247, inclusive, gave seg. *petiolaris* again in three of the families, 35244, 35245, 35247, which produced jointly 153 *decipiens*, 186 *erythrina*, 91 *petiolaris*, and 24 not exactly identified. The other two families of this same parentage, 35243 and 35246, contained no *petiolaris*, but consisted jointly of 144 *decipiens*, 150 *erythrina* and 32 not exactly identified.

Finding that *Oe.* seg. *petiolaris* could not be depended on to supply breeding material until too late in the season, and then in only a few individuals, I decided in 1937 to try the effect of long-day treatment. To this end I brought well grown rosettes of several types, including seg. *petiolaris*, to the greenhouse before freezing weather set in in the field and suspended about 50 cm above them a 500 watt incandescent lamp and above this a bright sheet of tin-plate as a reflector. This lamp was lighted at dusk each evening from December 1, 1937, on, and turned off regularly about 10 P.M. The plants responded to this treatment by developing stems which grew well and formed vigorous flowering specimens in mid-winter (Figs. 7, 8). I thus secured scores of fully developed flowers of *Oe.* seg. *petiolaris* which had rarely produced more than two or three flowers on any plant in the field.

FIG. 7. A single flower of *Oe.* seg. *petiolaris* compared with a flower of *Oe. Lamarckiana*. The latter is practically indistinguishable from a flower of *Oe.* mut. *erythrina*.

FIG. 8. A portion of an inflorescence of *Oe.* seg. *petiolaris* 36323(63), brought to full maturity by long-day treatment. Photo April 6, 1938.

In all details these flowers agreed with those produced naturally in the field, but unfortunately for my breeding program they were practically pollen sterile. I did succeed in getting several small capsules by applying pollen from *Lamarckiana rubrifolia* which was also receiving long-day treatment at the time, to the stigmas of *petiolaris.* These capsules contained 25 seeds which were sown on February 8, 1939, under the family number 38246, and produced 13 plants, all of which seemed to be *Lamarckiana rubrifolia,* though several of the smaller plants had the red pigmentation on the rosette leaves more broken and patchy than in their more vigorous sibs. There was thus a practically complete dominance in the F_1 of the paternal characteristics over the numerous peculiarities of seg. *petiolaris.*

Two families of the current year (1941) resulted from selfing two of these F_1 plants in family 38246. These two families 4098 and 4099, representing the F_2 of *petiolaris* × *Lamarckiana rubrifolia,* present a series of puzzling genetical problems.

Family 4098 from a patchy *Lamarckiana rubrifolia* parent consisted of 115 plants (from 300 seeds), only one of which approximated *petiolaris* by having the leaves reduced to petioles without conspicuous blades. All the rest were *Lamarcki-*

TABLE 1[1]

PROGENIES CONTAINING *Oe.* SEG. *petiolaris*, FROM SELF-FERTILIZED *Oe.* MUT. *erythrina* SIBS OF *petiolaris*

Grandparent Number	Parent Number	*De-cipiens*	*Ery-thrina*	*Petio-laris*	Other variants or doubtful
3351	3485	53	63	43	4
	35239	34	49	33	1
3485	35244	47	56	33	23*
	35245	42	46	26	4
	35247	64	69	32	12*
35239	36297	66	92	51	—
	36298	44	63	42	6
	36299	0	89	29	—†
	36300	42	63	29	—
	..	..	..	..	..
	..	..	..	..	..
36329	37466	73	48	44	3
	37467	54	100	59	—
	37468	47	71	47	—
	..	..	..	..	..
	..	..	..	..	..
37434	38513	64	88	57	—
	38515	47	107	54	—
	38516	18	56	28	109‡
	38517	58	109	48	—
	38520	12	23	16	—
	38529	29	47	36	23§
	38530	51	147	66	—
	..	..	..	..	..
	..	..	..	..	..
38516	39497	62	61	33	6
	39499	43	36	26	—
	39502	11	25	6	14**
	39504	3	26	11	19**
38296	39508	2	8	2	—
	39509	12	22	8	2
	39511	9	21	9	—
	..	..	..	..	..
	..	..	..	..	..
39497	40106	13	30	9	—
	40108	16	28	8	—
	40110	0	56	18	10††
	40111	13	27	14	1
	40113	31	38	30	4
	40114	18	37	15	1
	..	..	..	..	..
	..	..	..	..	..
Totals (159 families)		6479	9993	5467	360

[1] This table is abbreviated by the omission of 127 entries, including none in which mutational segregations seem to have been present. The complete table is issued through Auxiliary Publication, and may be obtained from the non-profit Bibliofilm Service, American Documentation Institute, 2101 Constitution Avenue, Washington, D. C., by ordering Document No. 1601, remitting 30 cents for copy in microfilm, readably enlarged full-size on reading machine or hand viewer, or **$1.00** for copy in form of paper photoprints readable without mechanical aid.

* These were smaller, darker green rosettes of unknown identity, probably a new mutational segregate.

† In this family *Oe.* seg. *petiolaris* appears to have replaced seg. *decipiens*, but as this is the only family in which this has been the case, it seems more likely that the *decipiens* is replaced here by seg. *sublethalis*, as discussed later in this paper.

‡ Of this group of 109 plants, 108 are assumed to have been *Oe.* seg. *diminua*, discussed in a later section of this paper.

§ These 23 were of *erythrina* form but definitely smaller, probably an unidentified mutational segregate.

** These were *Oe.* seg. *diminua.*

†† These ten plants were the new *Oe.* seg. *elongata* which is discussed in a later section.

ana rubrifolia(—) having the same defective pigmentation that characterized the parent, and implying that this patchiness of the pigmentation was genotypically determined. Thirty-two of the plants differed from the rest only in being relatively depauperate. A considerable number of the plants of this family had the young rosettes raised more or less above the ground on naked stems, 1–3 cm long.

Family 4099 is in striking contrast with 4098, for out of 185 plants secured from sowing 300 seeds only 15 were *Lamarckiana*-like, and 170 *petiolaris*. All of the former were *rubrifolia*, while none of the *petiolaris* showed any indication of *rubrifolia* pigmentation. The near disappearance of *Lamarckiana rubrifolia* in family 4099 and the all but complete disappearance of *petiolaris* in 4098, are notable features of these two F_2 families, since *petiolaris* is recognized as a recessive type. The explanation is presumably inherent in the distribution of the lethal factors possessed by the given parents.

That *Oe.* seg. *petiolaris* is not an alethal form, as I at first supposed, seems to be demonstrated by this result. I believe that such a hypothesis is rendered untenable also by the fact that seg. *petiolaris* has a circle of six and four pairs of chromosomes [2] exactly as in *erythrina*, not the seven pairs that would be expected in an alethal form which balanced the seven-paired seg. *decipiens*.

The unsatisfactory breeding potentialities of *Oe.* seg. *petiolaris* have led me to concentrate on the use of *erythrina* sibs for a continuation of my

[2] I am indebted to Dr. D. G. Catcheside of Cambridge University, England, for this determination. Dr. Catcheside visited my cultures on August 22, 1937 and finding a plant of seg. *petiolaris* in bud took material for a smear. He reported the result the following day.

studies of this new segregant, and particularly in studying the different types of families produced by this strain of *Oe.* mut. *erythrina.* These extensive breeding tests of many different individuals of *Oe.* mut. *erythrina* have led to the discovery of the other remarkable mutational segregations which are described in this paper. It is to be remembered, in what follows, that the several *erythrina* plants whose progenies are included in the tables and which have differed from one another genetically in various characteristic ways, have been quite indistinguishable from each other phenotypically; also that all the breeding has been by completely hand-controlled self-fertilizations. Most of the families from *erythrina* sibs of seg. *petiolaris* are assembled for record and study in Tables 1 and 2, but a few appear incidentally in subsequent tables. Only samples of Tables 1 and 2 are presented here. The complete tables are issued through Auxiliary Publication and is obtainable by purchase at cost from the American Documentation Institute, Washington, D. C. The other tables are published here in full. In Table 1 are given the progenies of *erythrina* sibs of *petiolaris* that showed *petiolaris* segregates, while

TABLE 2[1]

PROGENIES CONTAINING NO SEG. *petiolaris*, FROM SELF-FERTILIZED *Oe.* MUT. *erythrina* SIBS OF *petiolaris*

Grandparent Number	Parent Number	*Decipiens*	*Erythrina*	Other variants or doubtful
3351	3484	45	74	4
3484	35243	82	86	15*
3485	35246	58	68	17*
35239	36296	83	104	—
	36302	47	82	2
	36303	56	51	4
	36304	2	85	—†
	36306	70	64	—
	36308	70	81	2
	..	..	..	..
	..	..	..	..
36329	37462	62	109	—
	37464	66	114	1
	37467½	69	111	—
37414	38294	71	87	2
	38295	51	124	—
	38297	69	88	2
37419	38499	71	106	—
	38500	49	88	—
	..	..	..	..
	..	..	..	..
38300	39519	72	117	—
	39523	80	99	—
	39528	50	115	—
	39530	1	86	3†
39497	40103	31	47	—
	40104	32	52	—
	40105	36	70	—
	40107	32	78	—
	40109	50	53	—
	..	..	..	..
	..	..	..	..
Totals (109 families)		5625	10181	124

* Probably unidentified mutational segregations.

† In these two families seg. *decipiens* is assumed to be nearly or quite eliminated by an exchange with seg. *sublethalis* as discussed in a later section.

[1] This table is abbreviated by the omission of 83 entries, including none in which mutational segregations seem to have been present. The complete table is filed with the American Documentation Institute, Washington D. C. See footnote to Table 1.

TABLE 3

PROGENIES FROM SELF-FERTILIZED *Oe.* MUT. *erythrina* IN FAMILIES WHICH CONTAINED NO SEG. *petiolaris*, THAT IS, FROM FAMILIES LISTED IN TABLE 2

Grandparent Number	Parent Number	*Decipiens*	*Erythrina*	Other variants or doubtful
36321	37422	56	106	—
	37423	47	98	—
	37424	35	80	—
	37425	70	127	—
	37426	42	94	—
	37427	31	75	1
	37428	0	61	40*
	37429	31	84	—
	37430	21	61	—
	37431	19	47	—
36328	37446	16	44	1
	37447	31	43	—
	37448	70	92	3
	37449	67	116	1
	37450	69	139	1
	37451	56	119	3
	37452	81	101	2
	37453	39	90	2
	37454	52	68	—
	37455	71	115	—
	37456	73	127	—
Totals (20 families)		977	1826	14

* These 40 plants were *Oe.* seg. *contracta* which replaced *Oe.* seg. *decipiens* in this family as will be recounted in the next section of this paper. This family is not included in the totals at the bottom of the table.

in Table 2 are the progenies of the same origin which produced no *petiolaris* segregates. By reference to the totals at the bottom of Table 1 it will be seen that 157 of the listed *erythrina* sibs of *petiolaris* have yielded progenies consisting of the three main categories, *decipiens, erythrina* and *petiolaris,* while Table 2 shows that in 109 families of corresponding origin the main categories are only the two already familiar ones, *erythrina* and *decipiens.* From this it appears that the *erythrina* sibs of seg. *petiolaris* are, in nearly equal numbers, of two kinds with respect to their ability to segregate out a group of *petiolaris* plants in their offspring.

When we breed the *erythrina* plants in the families of Table 2, which contained no *petiolaris,* we find that the ability to produce *petiolaris* has apparently completely disappeared, as may be noted in Table 3, in which 20 such progenies are given. In this group of twenty families there was an exceptionally close approximation to the 1:2 ratio of *decipiens* and *erythrina.* There were 54 aberrant or doubtful individuals, but not one of these showed any resemblance to seg. *petiolaris.* In other words there seems to be a perfect segregation of the ability of mut. *erythrina* to segregate a class of *petiolaris.*

FIG. 9. Portion of seedpan 37428 containing *Oe.* mut. *erythrina* and the first appearance of *Oe.* seg. *contracta,* about three weeks after germination. No seg. *decipiens* occurs in this culture. Photo March 20, 1938.

Oenothera seg. *contracta,* seg. nov.

The next example of unexpected mutational segregation from *Oe.* mut. *erythrina* was discovered March 20, 1938, in a seedpan bearing the family number 37428. The plants in this pan were about three weeks old, but were easily distinguished as belonging to two strongly contrasted phenotypes, of which one was apparently *erythrina,* the other a much smaller remarkably dark green, heavily crinkled, shining form which was at once named *Oe.* seg. *contracta* (Fig. 9). This family appears in the first section of Table 3, where all of the tested sibs of its parent are recorded. It was notable because its progeny consisted of 61 *erythrina* and 40 seg. *contracta,* instead of splitting in a 2:1 ratio of *erythrina* and seg. *decipiens.* In other words, seg. *contracta* has completely replaced seg. *decipiens* in this family. Figure 10 shows the two phenotypes present in this family and Fig. 11 allows a comparison of the new seg. *contracta* and the seg. *decipiens* which seg. *contracta* has displaced.

The plants of seg. *contracta* are very hardy and there are practically no losses in the seedpan nor in pots in the greenhouse, but they are of slow growth and notably smaller than *erythrina* or seg. *decipiens* of the same age. They also withstand well being reset to the field, but have never begun to form stems in the field. The seg. *contracta* plants in family 37428 began to die after they had grown for some time in the field, and by mid-August all had died. I was not greatly concerned over their loss, since it was obvious that they would never proceed beyond the rosette stage. Because of their obvious replacement of seg. *decipiens* in this family, I predicted that every *erythrina* plant in this family, if selfed, would give seg. *contracta* and mut. *erythrina* again in about the ratios which would otherwise have been presented by seg. *decipiens* and mut. *erythrina.*

To test the validity of this assumption I self-pollinated eleven *erythrina* sibs of these first seg. *contracta* plants and grew the resulting progenies in 1939. The record of one of these families (38314) was unaccountably lost. The remaining ten families, with eleven progenies grown from similar parentage in 1940, are presented together

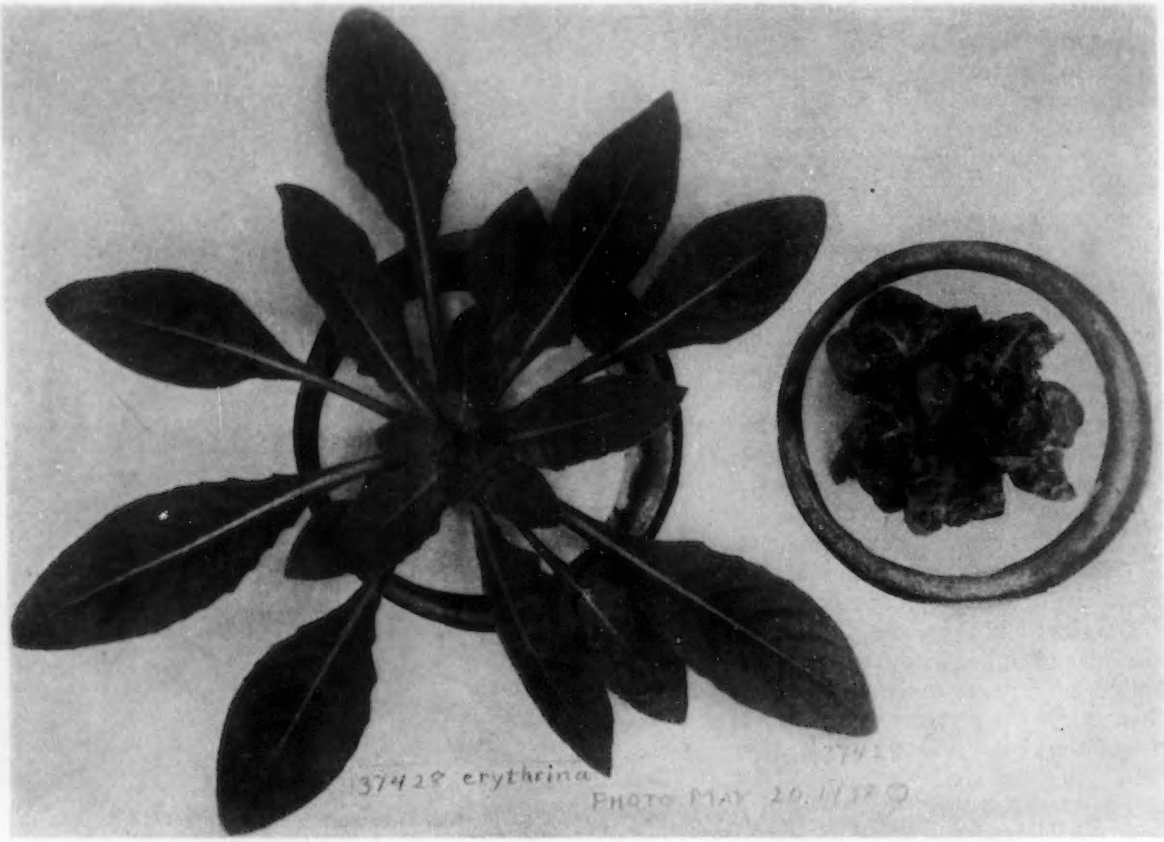

FIG. 10. Rosettes of *Oe.* mut. *erythrina* and seg. *contracta*, the only two types occurring in family 37428. Photo May 20, 1938.

with the original family 37428, in Table 4, where it is seen that every one of these *erythrina* parents produced the expected segregation of *erythrina* and seg. *contracta*, with a considerable excess of *contracta* over the one-third theoretically expected. This excess accords with the excess of seg. *decipiens* commonly found in the progenies of the original normal mut. *erythrina*. A notable feature of the families in this table is that in each of two of these families, 39536 and 39540, there was a single specimen of typical seg. *decipiens*. These two families taken together consisted of 80 *contracta*, 160 *erythrina* and 2 *decipiens*. Since seg. *contracta* has replaced seg. *decipiens*, these two *decipiens* plants suggest the possible occurrence of reverse mutation. Such a suggestion may be borne in mind in other cases where seg. *decipiens* has unexpectedly reappeared.

Two of the families in Table 4 are unique in having each a third segregated group in addition to mut. *erythrina* and seg. *contracta*. Family 39531 had in addition to 59 *contracta* and 66 *erythrina*, a group of 24 plants described as "darker and smaller than *erythrina*, but velvety, slightly crinkled, with repand denticulations." This group represents undoubtedly a new mutational segregation, but inadequate attention was given to these plants, and consequently their identity remains in doubt. The other family, 39533, had besides 25 seg. *contracta* and 61 mut. *erythrina*, a group of 16 *Oe.* seg. *cyanea* which will be discussed in the next section of this paper.

As stated above, all the *contracta* plants in the original family 37428 had died by mid-summer of 1938. The same result was experienced in the *contracta*-containing families in 1939, so that it was impossible to use long-day treatment to promote their maturation, which I had found effective in the case of seg. *petiolaris* and in some other retarded forms. Steps were taken in 1940 to keep *contracta* plants alive, if possible, for a longer time. To this end the *contracta* group of family

Fig. 11. Young rosette of *Oe.* seg. *contracta* (37428) and *Oe.* seg. *decipiens* (3785), the form which seg. *contracta* replaced in culture 37428. Photo April 25, 1938.

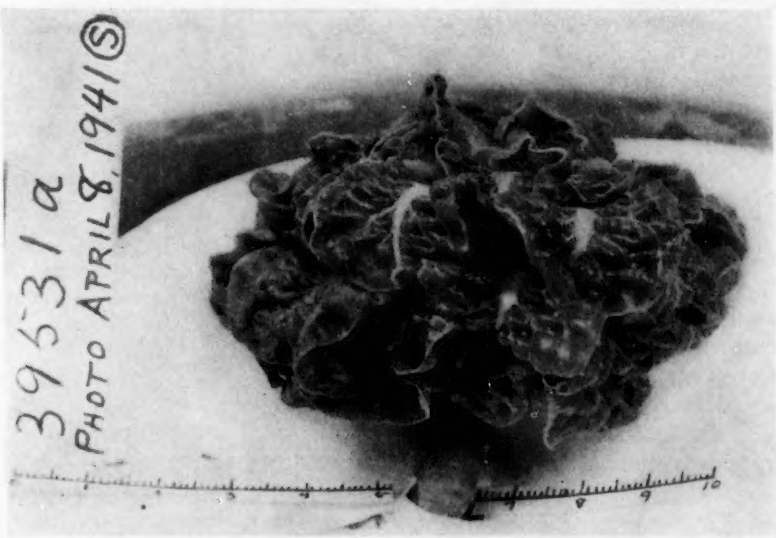

Fig. 12. A rosette of *Oe.* seg. *contracta* (39531), thirteen months old, which received long-day treatment daily from November 1940 to April 1941. Photo April 8, 1941.

TABLE 4

PROGENIES OF SELF-FERTILIZED *Oe.* MUT. *erythrina* IN WHICH SEG. *decipiens* HAS BEEN REPLACED BY SEG. *contracta*

Grandparent Number	Parent Number	*Contracta*	*Erythrina*	Other variants or doubtful
36321	37428	40	61	—
37428	38304	108	77	—
	38305	102	93	3
	.38306	128	110	—
	38307	108	80	—
	38308	87	84	1
	38309	96	100	—
	38310	97	103	—
	38311	90	98	—
	38312	52	72	—
	38313	83	98	—
38305	39531	59	66	27*
	39532	39	87	—
	39533	25	61	20†
	39534	41	96	—
	39535	31	69	3
	39536	54	74	1
	39537	51	88	1
	39538	66	72	1
	39539	47	71	6
	39540	49	90	1
	39541	17	45	—
Totals (22 families)		1470	1795	64

* 24 of these were of a new undescribed mutational segregation.

† 16 of these were *Oe.* seg. *cyanea*, as described in a later section of this paper.

39531 was not set to the field, but the plants were given various treatments in or near the greenhouse where they could be under constant observation and given needed attention to prevent injury from drought or other unfavorable conditions. One group, set in a bed of earth in the greenhouse, were soon eliminated by fungus disease, but of 8 plants set in large pots and sunk in a flower-bed near the greenhouse one survived until fall and passed the winter in good health under long-day treatment, but showed no inclination to run up a flowering stem. As new leaves formed above, the old leaves disappeared below, thus resulting in a maximum-sized rosette borne at the top of a very slowly elongating heavy stem (Fig. 12).

Another group of 32 of these *contracta* plants was set in a coldframe and protected by a lattice-work screen from too effective action of the sun. Many of these continued to grow slowly during the summer, and greatly to my surprise, five which over-wintered in the coldframe, began quite early in the spring of 1941 to form stems. All of these have continued to grow and have developed stems from 60 to 80 cm tall (Fig. 13). It will be noted that there are no basal branches but some branching toward the tops of the main axes. Early in

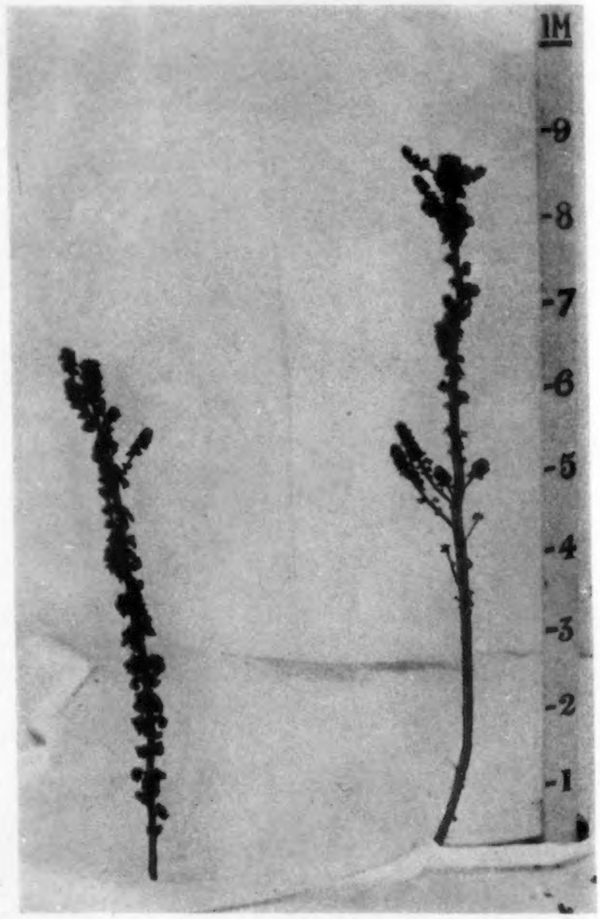

FIG. 13. Habit of mature *Oe.* seg. *contracta* (39531), sixteen months old. These wintered in a coldframe but were not given artificial lighting. Photo July 15, 1941. Compare with habit of *Oe.* mut. *erythrina* shown in Fig. 5.

July, 1941, several of them began to show bud-tips on the knoblike ends of the stems. The growth of these proceeded very slowly and it was fascinating to see a few of these buds enlarge, then show the development of the characteristic *erythrina* pigmentation on the bud-cones. But it was very disappointing to find that these enlarging buds had been induced to develop, only by the development within each of them of a larva of

FIG. 14. *Oenothera* seg. *contracta* inflorescence with bud-galls produced by *Mompha stellella* Busck. Photo July 18, 1941.

Mompha stellella Busck, an insect which produces familiar bud-galls on other species of Oenothera, as described long ago by Gates (1910), and well known to all American growers of Oenothera cultures. A growing doubt that normal buds would be produced by these plants led to a more careful study of these galls than otherwise would have seemed necessary. The remarkable bud-cones of these galled buds reach a size of 12 mm long not including the free tips and 12 mm wide, and the heavy well-separated free tips were 4–5 mm long (Fig. 14). It was recognized that the form and size of these bud-galls would give little hint as to the form and dimensions which would be seen in normal buds of *Oe.* seg. *contracta,* should these ever develop. They differ from the corresponding bud-galls of *Oe.* mut. *erythrina, Lamarckiana,* etc., in remaining closed or only with an insignificant split between the sepals in the proximal portion of the cone where bud-galls of other forms split widely thus conspicuously displaying the petals. The bud-galls of seg. *contracta* are thus short barrel-shaped or cylindrical instead of roughly cone-shaped as in other forms. When the calyx is removed the corolla is seen to be tightly packed and very crumpled, with a thickened inward fold along the median line of each petal. The essential organs of the flower are completely ruined by the intruder, the style and stigmas being eaten out and the filaments of the stamens abnormally shortened and thickened, and anthers are missing or are flat disks of tissue scarcely recognizable as anthers. The hypanthium is reduced to a very short thick obconical structure which gives no hint as to whether the natural hypanthium will be *pollicata* or will have the normal tubular form. The presence or absence of a solid hypanthium is a very important question here, since seg. *contracta* has replaced seg. *decipiens pollicata.*

After watching the development of about a dozen of these bud-galls, while all the other buds seemed inclined to remain small four-pointed stars consisting of the widely divergent free tips, I

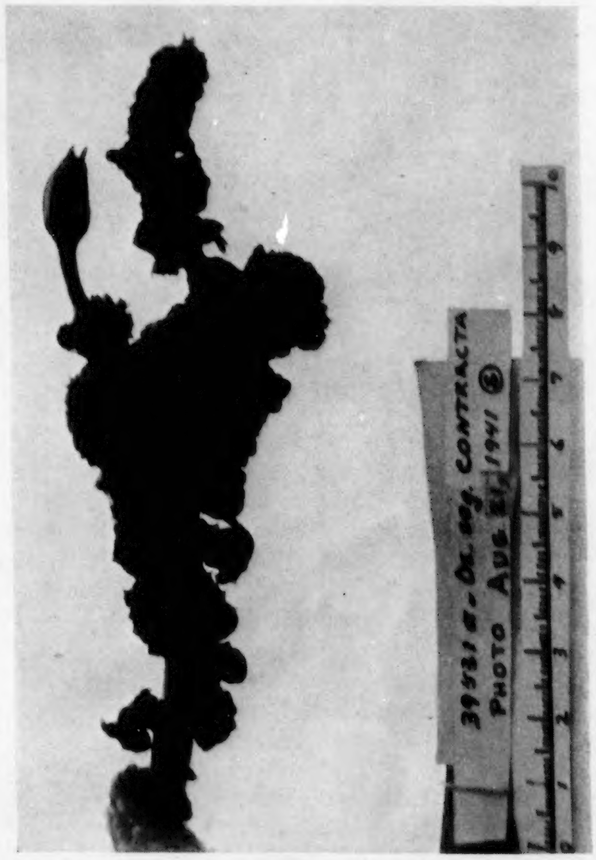

FIG. 15. *Oenothera* seg. *contracta* showing a normal bud on the day preceding anthesis. A very slight increase in diameter of the hypanthium marks the limit between solid and tubular part of the hypanthium. Photo August 21, 1941.

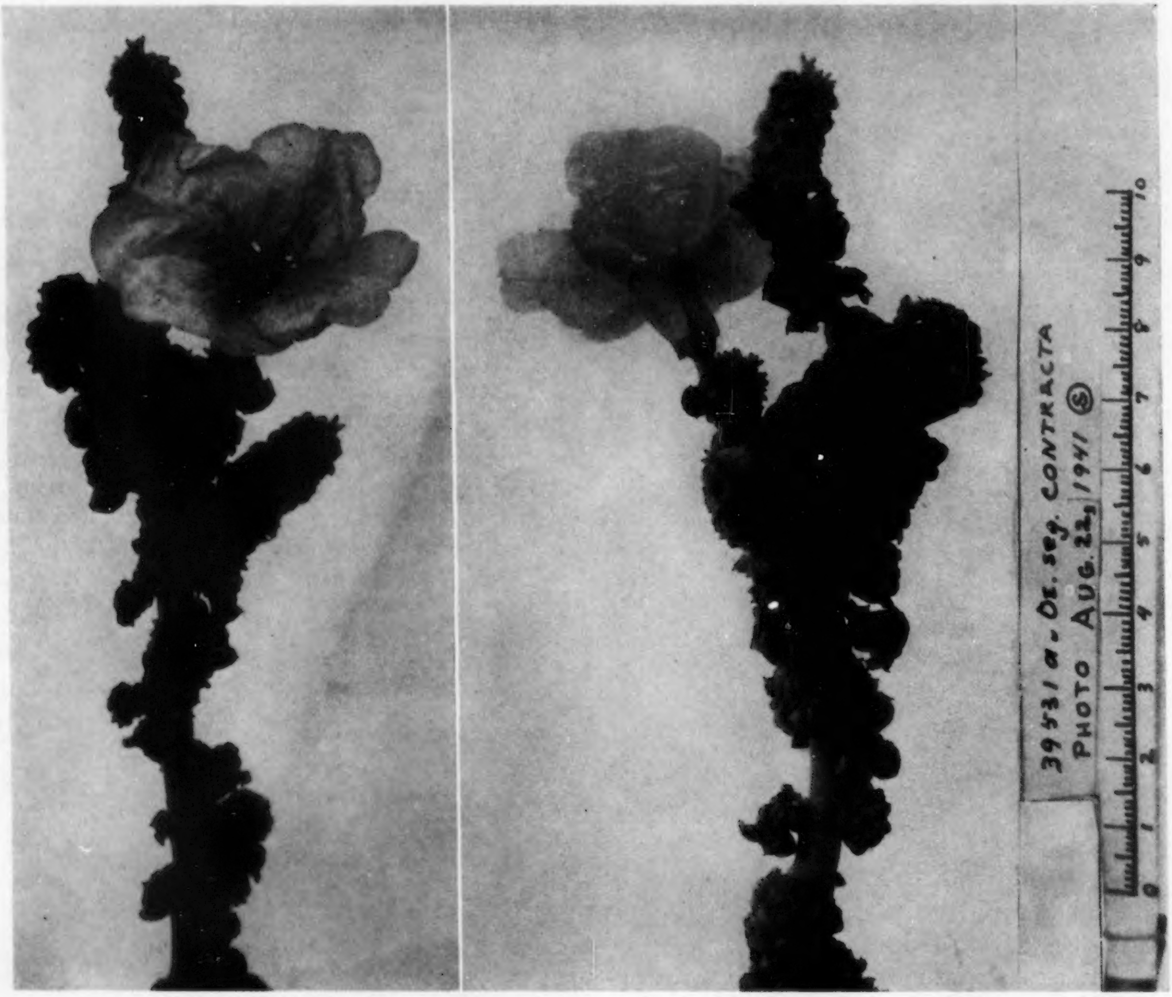

FIG. 16. A normal flower of *Oe.* seg. *contracta.* The rear view shows the broad short sepals nearly hiding the hypanthium.

surmised that no normal buds would be produced, and that the normal flowers of seg. *contracta* would remain forever unknown. In this I was happily mistaken, for about August 1 I noticed the enlargement of several buds which did not show the swollen flaring hypanthium of the Mompha galls, and I gradually became convinced that here at last normal buds were developing. These normal buds (Fig. 15) did not differ as much from the bud-galls, however, as I expected, the main differences being that the normal bud-cone does not attain as large size as the galls and is less intensely reddened, though showing the *erythrina* type of reddening on the cones. The fully developed bud on the day preceding anthesis had a hypanthium 10–15 mm long, topping an ovary 5–6 mm long, and cones were about 10 mm long and 7–8 mm in diameter, the free tips 4 mm long, erect or slightly divergent. Approximately one-half of the hypanthium was solid, thus indicating that seg. *contracta* is *pollicata* like the seg. *decipiens* it has displaced.

The enlargement of these buds proceeded slowly, but finally the first flower opened on August 8, the second on August 11, a third on August 13 and a fourth on August 22, 1941 (Fig. 16). These flowers were on three different plants, but were all essentially uniform, except that the first one had a slightly blighted style and stigma and the flower as a whole was only three-fourths as large in diameter as the later healthy flowers (32 mm as compared with 44–45 mm). As compared with *Oe.* mut. *erythrina,* a single petal of the latter would just cover the entire normal flower of seg. *contracta.* As anticipated the petals are notably wider than long, 25–28 mm wide and 18–22 mm long, and extremely crinkled. Occasionally a petal has one or two conspicuous notches in the distal margin. The anthers are crooked and usually devoid of pollen, but a small quantity of seemingly good pollen has been produced on the later flowers. The style and stigma are typical *pollicata,* the styles being limp and the stigmas heavy and clumsy, so that they decline in positions determined mainly by gravitation.

Oenothera seg. *cyanea,* seg. nov.

I have already mentioned, in the last section, two families which are entered in Table 4, but which differed from the other families in that table by

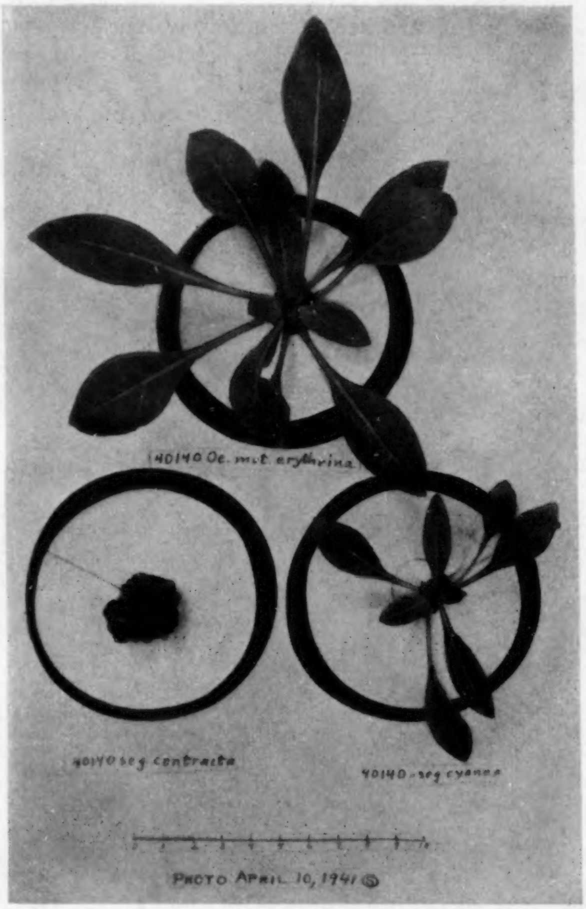

FIG. 17. The three segregates in a family (40140) in which *Oe.* seg. *cyanea* was added to the expected *Oe.* mut. *erythrina* and *Oe.* seg. *contracta.* Photo April 10, 1941.

FIG. 18. *Oenothera* seg. *contracta,* in family 40140, six weeks after setting in the experimental field. Photo June 28, 1941.

having, in addition to the two expected phenotypes, *erythrina* and *contracta,* a third unexpected segregating group. In family 39533 such an unexpected group was observed on May 23, 1940, and subsequently given the name seg. *cyanea* because of the notably more bluish-green color. The leaves of this form are considerably narrower, more nearly entire, rather shining and less crinkled than in mut. *erythrina* (Figs. 17 and 19). Like the other segregates from mut. *erythrina,* seg. *cyanea* is of relatively slow growth and has thus far shown no indication of developing a stem in the experimental field, but several rosettes taken into the greenhouse and given long-day treatment were readily brought to sexual maturity, the first flower coming to bloom January 21, 1941. The stem leaves, like the rosette leaves, are narrower and more bluish than the corresponding leaves of *erythrina.* The buds are more slender, but similar as to red pigmentation on the bud-cones. The petals are slightly smaller than in *erythrina,* and tend to be slightly irregular distally with occasionally a lateral lobe reminiscent of *Oe.* mut. *spathulata* de Vries, one of the trisomic mutants. The petals are almost exactly as wide as they are

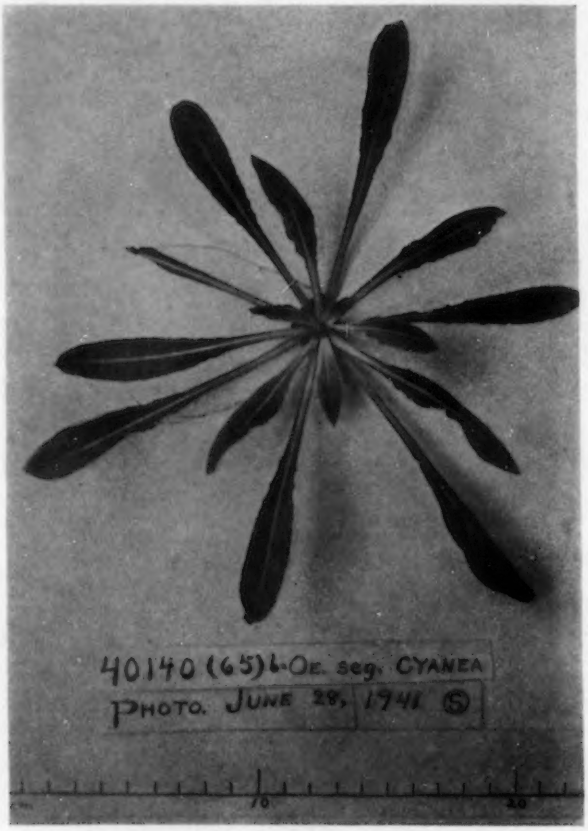

FIG. 19. *Oenothera* seg. *cyanea*, of the family shown in Fig. 17, six weeks after setting in the experimental field. Photo June 28, 1941.

long, 27–30 mm long × 25–28 mm wide; in other words, they are slightly smaller and relatively narrower than in *erythrina;* (petals of *Oe.* mut. *erythrina* measure about 34–40 mm long and 45–48 mm wide). The flowers of seg. *cyanea* produced a good supply of pollen, and seeds have been secured both from selfings and from crosses.

Since the *cyanea* segregation adds a third group to a family which was expected to have only the two groups, *erythrina* and seg. *contracta*, it may be assumed that it bears the same genetical relationship to these two groups that seg. *petiolaris* bears to *erythrina* and seg. *decipiens* of the usual strains of *erythrina*. To test this relationship 58 *erythrina* plants in family 39533 were selfed and the resulting progenies grown in 1941 under consecutive family numbers 40135 to 40192, inclusive. Just as *erythrina* sibs of seg. *petiolaris*, when self-fertilized, produce two kinds of progenies, some producing *petiolaris* again while others produce only *erythrina* and *decipiens*, so also it is found that these *erythrina* sibs of seg. *cyanea* are genetically of two kinds though phenotypically indistinguishable.

These progenies are collected into the two tables, 5 and 6, Table 5 containing all the progenies which included a *cyanea* group and Table 6 all those which consisted of *erythrina* and seg. *contracta* only. The relative numbers of families in these two tables, 36:26, correspond closely with the numbers in the *petiolaris* series presented in Tables 1 and 2, namely, 159 to 109; for 159:109 = 36:24.7. Much stress must not be laid on this nearly exact duplication of these two ratios, as it may possibly be a mere coincidence, but even if the ratios were less exactly equal the assumption seems to be substantiated that the genetical significance of seg. *petiolaris* in the *decipiens*-bearing families is identical with that of *cyanea* segregates in *contracta*-bearing families. A further test of this conclusion is available, but must await the growing of another generation, when *erythrina* plants from families listed in Table 5 should again give a similar ratio of two kinds of families, while *erythrina* plants from families listed in Table 6

FIG. 20. *Oenothera* mut. *erythrina*, in family 40140 six weeks after setting in the experimental field. Photo June 28, 1941.

TABLE 5

PROGENIES CONTAINING SEG. *cyanea*, FROM SELF-FERTILIZED MUT. *erythrina* SIBS OF SEG. *cyanea*

Grand-parent Number	Parent Number	*Contracta*	*Erythrina*	*Cyanea*	Other variants or doubtful
38305	39533	25	61	16	4
39531	40131	11	38	6	2
39533	40135	49	47	13	2
	40139	69	71	19	—
	40140	42	68	19	5
	40142	22	28	6	—
	40143	56	59	18	4
	40145	47	61	20	5
	40146	37	45	10	—
	40148	8	23	4	—
	40151	45	67	18	3
	40153	33	44	6	—
	40154	63	72	10	—
	40157	27	61	4	—
	40158	41	56	24	2
	40160	15	50	3	—
	40161	36	85	16	—
	40163	18	39	5	1
	40164	29	53	8	—
	40166	41	54	12	3
	40168	23	50	1	2
	40170	39	44	4	2
	40172	33	44	11	—
	40174	31	45	4	—
	40175	33	45	8	—
	40176	25	62	14	—
	40177	30	49	12	1
	40178	50	68	14	—
	40179	43	75	13	5
	40180	35	70	23	—
	40181	52	83	9	1
	40184	44	31	4	—
	40185	65	88	11	—
	40188	52	77	18	—
	40189	30	47	7	1
	40192	35	56	17	4
Totals (36 families)		1334	2016	407	46

should give no case of segregated *cyanea* in the next generation.

Oenothera seg. *diminua*, seg nov.

On May 16, 1939 I found that many of the 207 plants which had been potted in one of my *petiolaris*-bearing families (38516) had died and that there remained 17 plants so diminutive that it was clear that they would not survive to be set into the field. It is probable that nearly all of the 91 plants which had died before this date were of this same depauperate form. I assume therefore that this family was made up of about 108 seg. *diminua*, 18 seg. *decipiens*, 56 *erythrina*, and 28 seg. *petiolaris*. Two of the *petiolaris* were also

TABLE 6

PROGENIES CONTAINING NO SEG. *cyanea*, FROM SELF-FERTILIZED *erythrina* SIBS OF SEG. *cyanea*

Grandparent Number	Parent Number	*Contracta*	*Erythrina*	Other variants or doubtful
39531	40132	23	50	—
	40133	8	31	—
	40134	14	52	2
39533	40137	45	72	—
	40138	93	94	—
	40141	82	85	7
	40144	55	68	5
	40147	12	33	—
	40149	21	43	—
	40150	17	27	—
	40152	47	96	2
	40155	12	24	—
	40156	39	90	—
	40159	66	89	4
	40162	47	68	—
	40165	45	79	2
	40167	14	40	—
	40169	42	86	3
	40171	21	45	—
	40173	30	59	1
	40182	44	87	—
	40183	64	84	2
	40186	20	94	1
	40187	74	95	1
	40190	17	30	1
	40191	32	76	—
Totals (26 families)		984	1697	31

TABLE 7

PROGENIES CONTAINING *Oe.* SEG. *diminua*, FROM SELF-FERTILIZED *erythrina* SIBS OF SEG. *diminua*

Grand-parent Number	Parent Number	*De-cipiens*	*Ery-thrina*	*Diminua*	*Petio-laris*	Other vari-ants or doubt-ful
37434	38516	18	56	108	28	1
38516	39498	14	71	49	—	1
	39501	0	74	24	—	—
	40666	3	37	16	—	2
	39502	11	25	14	5	—
	39503	0	26	13	—	—
	39504	3	26	19	10	—
	39505	7	53	47	—	—
	39506	15	64	39	—	3
Totals (9 families)		71	329	432	43	7

TABLE 8

Progenies Which Contained no *Oe.* seg. *diminua* from Self-fertilized *Oe.* mut. *erythrina* Sibs of seg. *diminua*

Grandparent Number	Parent Number	*De-cipiens*	*Ery-thrina*	*Petio-laris*	Other variants or doubtful
38516	39496	0	2	—	—
	39497	62	65	33	2
	39499	43	36	26	—
	39500	49	95	—	—
Totals (4 families)		154	198	59	2

diminua, and are duplicated in this formal ratio.

To study this new segregation, eleven *erythrina* plants of family 38516 were self-pollinated and their progenies were grown in 1940 under the consecutive family numbers, 39496 to 39506, inclusive. The results are given in Tables 7 and 8.

Table 7 includes all of the families which again contained seg. *diminua,* together with the original family, 38516, while Table 8 includes the four families of like origin which contained no seg. *diminua.* Family 39496 had only two plants, both *erythrina,* and may or may not belong in this table. They are included here merely for the sake of completeness of the record. In two families, 39501 and 39503, seg. *diminua* seems to have completely replaced seg. *decipiens,* while in all the other families of Table 7 seg. *decipiens* was present, but in strikingly reduced proportion. The totals for these five families show only 39 seg. *decipiens* to 195 *erythrina* and 135 seg. *diminua.* In 1941 I have repeated family 39501 under the family number 40666. A portion of the seedpan of this family is shown in Fig. 21, where the great contrast in size between *erythrina* and seg. *diminua* can be readily seen. Reference may be made also to Fig. 28, where *Oe.* seg. *diminua* may be compared with all the other mutational segregates here described except *Oe.* seg. *sublethalis.* It will be noted that this new test of the parent of 39501 shows again that the *Oe.* seg. *decipiens* has not been completely replaced, but only greatly reduced in the presence of seg. *diminua.* In two

Fig. 21. Portion of seedpan 40666 showing *Oe.* mut. *erythrina* and *Oe.* seg. *diminua* which has practically replaced *Oe.* seg. *decipiens* in this family.

families, 39502 and 39504, seg. *petiolaris* was also present, and in the former one plant and in the latter two plants seemed to represent the combination, *petiolaris diminua*. When setting family 40666 to the field on May 23, 1941, all of the seg. *diminua* were set to a box of soil in the greenhouse, but by June 12, all had died.

In 1941 I have 12 families from selfed *erythrina* plants in family 39497 and 8 families from *erythrina* plants in family 39499. As both of these parental families contained no seg. *diminua*, these families give an answer to the question whether seg. *diminua*, like seg. *petiolaris* and seg. *cyanea*, can be transmitted only by *erythrina* plants which are sibs of the particular segregant under discussion. The results from these families, together with 3 similar families grown in 1940, are presented in Table 9 and show that there was not a single specimen of seg. *diminua* among the 1,947 plants included in these 23 families. In other words the ability to produce seg. *diminua* is lost permanently from the *erythrina* component of any family in which these *erythrina* plants had no seg. *diminua* sibs.

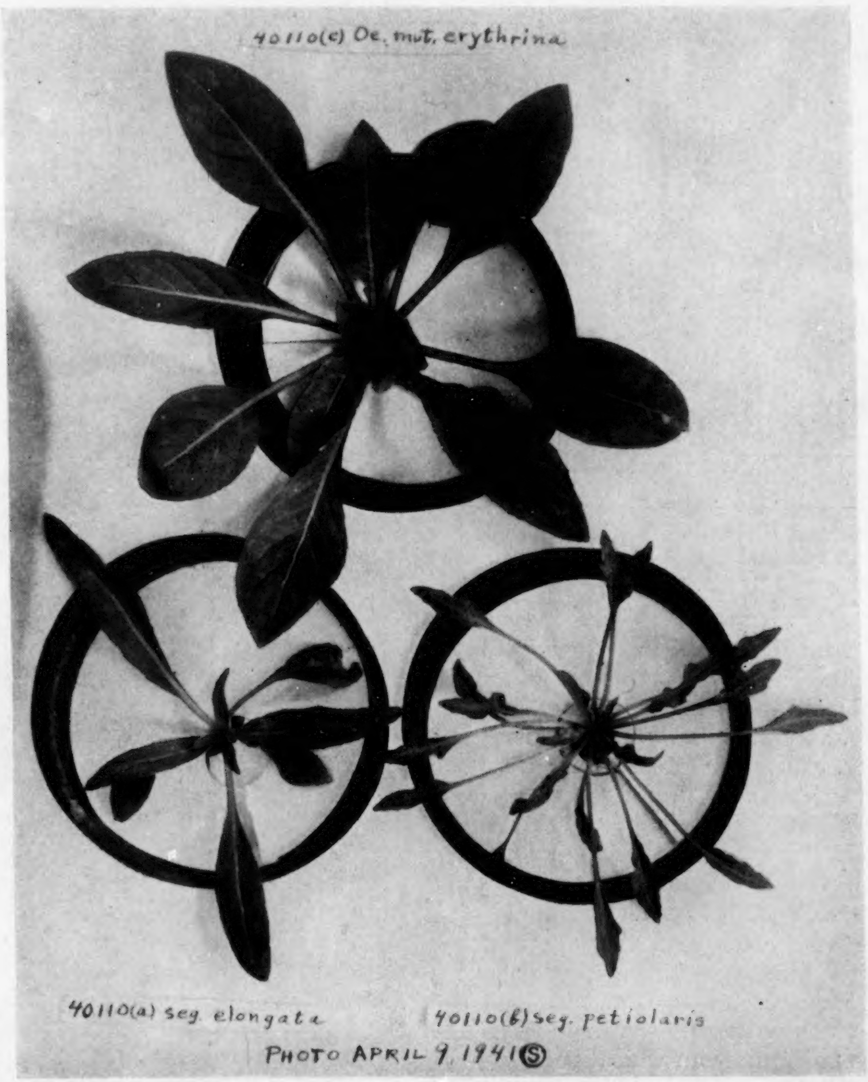

FIG. 22. *Oenothera* seg. *elongata* (lower left) which appeared in family 40110 completely replacing the expected *Oe.* seg. *decipiens*. The parent type, *Oe.* mut. *erythrina*, is shown above and *Oe.* seg. *petiolaris*, which was also present in this family, at lower right. Photo April 9, 1941.

TABLE 9

PROGENIES FROM SELF-FERTILIZED *Oe.* MUT. *erythrina* IN FAMILIES WHICH CONTAINED NO SEG. *diminua*, THAT IS, FROM FAMILIES LISTED IN TABLE 8

Grandparent Number	Parent Number	*De-cipiens*	*Ery-thrina*	*Petio-laris*	Other variants or doubtful
38516	39497	62	61	33	6
	39499	43	36	26	—
	39500	49	95	—	—
39497	40103	31	47	—	—
	40104	32	52	—	—
	40105	36	70	—	—
	40106	13	30	9	—
	40107	32	78	—	—
	40108	16	28	8	—
	40109	50	53	—	—
	40110	—	56	18	10*
	40111	13	27	14	—
	40112	27	43	—	—
	40113	31	41	31	1
	40114	18	37	15	1
39499	40115	22	56	—	—
	40116	30	52	—	1
	40117	41	73	—	—
	40118	12	20	6	—
	40119	34	41	21	2
	40120	17	25	13	—
	40121	28	49	—	—
	40122	5	14	6	—
Totals (22 families)		642	1028	182	11

* These were *Oe.* seg. *elongata*, as indicated in Table 1. This family is omitted from totals at foot of the table.

Oenothera seg. *elongata*, seg. nov.

In Table 9 it may be noted that family 40110 was in remarkable contrast with the other 22 families of that table in that it had, in place of the *decipiens* group, an entirely new group which has been named seg. *elongata*, because of the notably longer, narrower leaves. This form was discovered on April 8, 1941, and described on that date as follows: "The first several leaves are *erythrina*-like after which the leaves become stiff, with some lateral veins running almost parallel with mid-rib and margin. Blades often somewhat asymmetrical, the margins somewhat irregularly shallow-repand." A young rosette as of the date when this description was written is shown in Fig. 22 with the other two forms with which it was associated in family 40110. On June 26, 1941, these plants were examined in the field and the rosette leaves of seg. *elongata* were described as "narrow lanceolate, denticulate, often irregularly trough-shaped." The seg. *elongata* rosettes are shown in Figs. 23 and 28 for comparison with seg. *decipiens* (Figs. 24 and 28) which they have clearly replaced in this family and a typical stem leaf from a point about 30 cm above the rosette is shown for comparison with other relevant forms in Fig. 29. It will be interesting to observe whether the *erythrina* sibs of seg. *elongata* behave consistently in the same manner as the sibs of seg. *contracta*, by producing progenies consisting generally of *erythrina* and seg. *elongata* with seg. *decipiens* nearly or completely omitted. One of the *elongata* plants, 40110 (6), more precocious than the rest, came to bloom in the end of July, and several others have started stems, thus indicating that seg. *elongata* tends to be more precocious than most of the other new forms. This first flowering specimen is shown in Fig. 25. The stem leaves show a continuation of the long lance-like form of the rosette leaves as may be seen by reference to Fig. 29. Buds are more slender than those of *erythrina*, the free tips being more slender and rather closely approximated. The hypanthium of this first specimen to bloom is long and tubular throughout, and none of the other characters

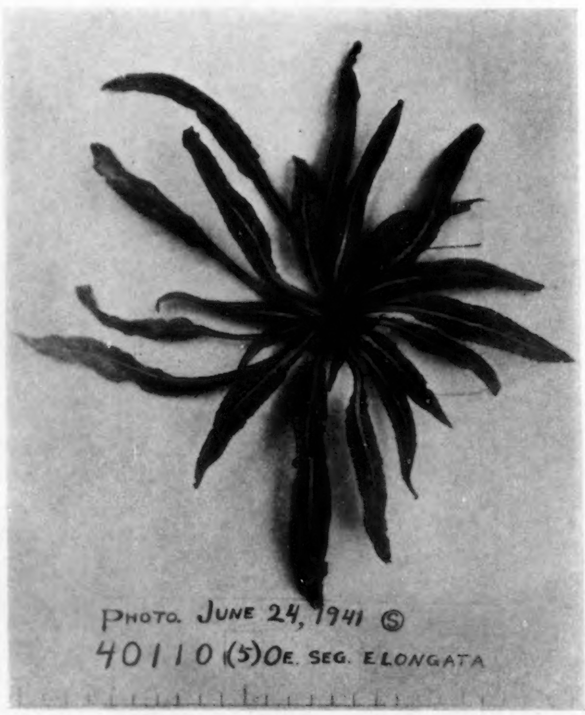

FIG. 23. *Oenothera* seg. *elongata* (40110) six weeks after setting in the experimental field. Photo June 24, 1941.

suggests any relation to *pollicata*. The flowers are not noticeably different in form and size from those of *Oe.* mut. *erythrina*. The second plant of seg. *elongata* to reach maturity (40110(5)) differs from the first, by having typical *pollicata* buds and flowers. This inclusion of both *pollicata* and non-*pollicata* plants in the seg. *elongata* group presents an interesting problem for further study. In none of the other new segregants has there appeared such a split with respect to an important characteristic. It seems barely possible that the seg. *elongata* group may be divisible into two groups, an *erythrina elongata* and a *decipiens elongata*, but the evidence for such a distribution is still too meager.

Oenothera seg. *retracta*, seg. nov.

It will be recalled that family 39531 (see Table 4), among the seg. *contracta* families, contained, in

FIG. 24. Field-grown rosette of *Oe.* seg. *decipiens* 35245(37) for comparison with seg. *elongata* in Fig. 23. The *decipiens* rosette is three weeks older but at a comparable stage of development. Photo July 18, 1936, by W. H. Brittingham.

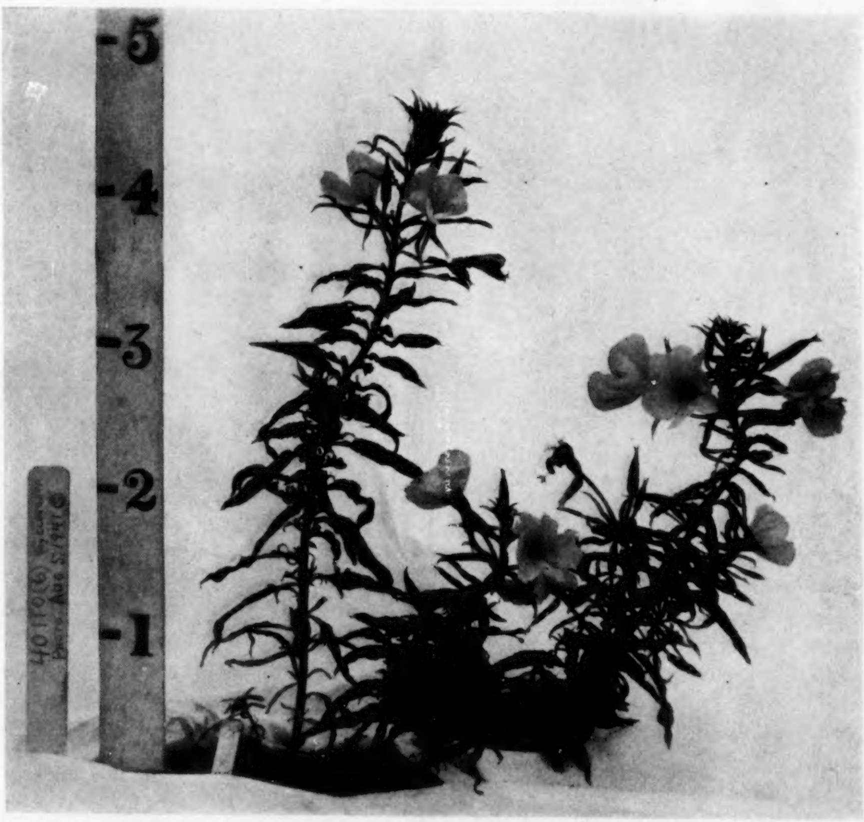

FIG. 25. Habit of the first specimen of *Oe.* seg. *elongata*, 40110(6), which reached the flowering stage. Photo August 5, 1941.

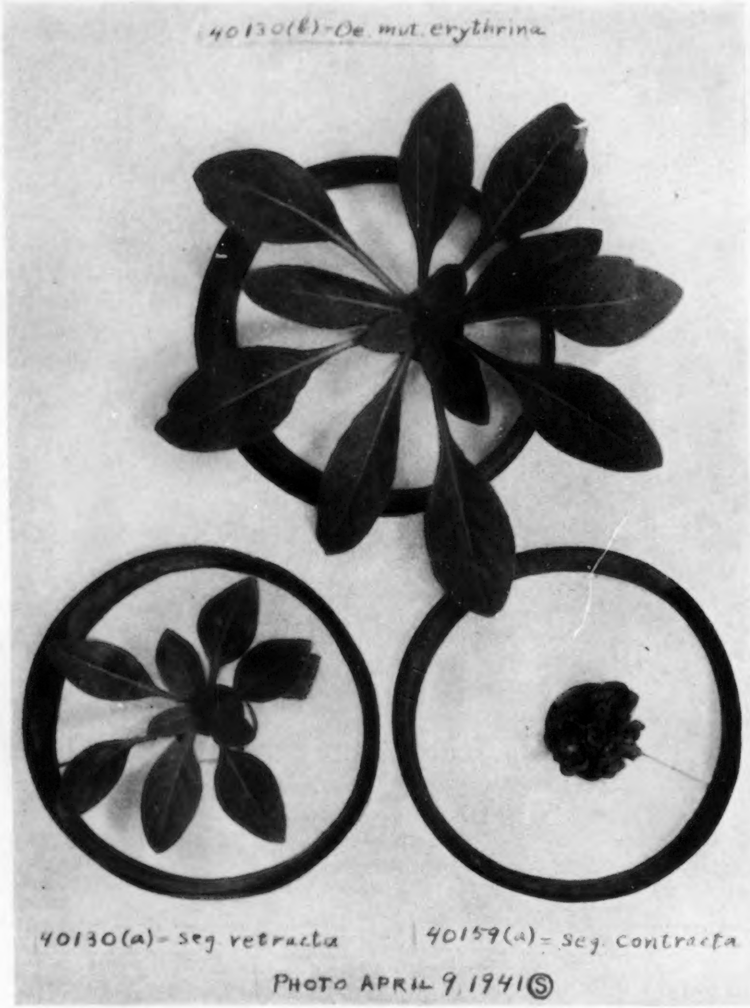

FIG. 26. *Oenothera* mut. *erythrina* and *Oe.* seg. *retracta* (lower left), the two types found in family 40130, where only *erythrina* and seg. *contracta* were expected. *Oe.* seg. *contracta* of same age from another family (40159) is included for comparison with seg. *retracta*. Photo April 9, 1941.

addition to *contracta* and *erythrina,* a new group whose identity remained in doubt. To get further information regarding the segregations in this family five of the *erythrina* plants were self-pollinated, and the resulting progenies were grown this year under the consecutive numbers 40130 to 40134, inclusive. Three of these families have consisted jointly of 45 *contracta,* 134 *erythrina* and 2 slightly aberrant plants of unknown identity. Family 40131 consisted of 11 seg. *contracta,* 6 seg. *cyanea,* 37 *erythrina* and 2 slightly aberrant.

But most notable was family 40130 in which a new uncrinkled segregate similar to mut. *erythrina* but smaller and darker green completely replaced seg. *contracta* (Fig. 26). These were observed on April 8, 1941, and have been recorded as seg. *retracta.* There were 9 of these to 32 *erythrina.* Four of the smaller *erythrina* plants were at first grouped with the seg. *retracta,* but after setting these to the field, they soon became typical *erythrina* plants, while all of the seg. *retracta* plants died. This remarkable replacement of seg. *contracta* by seg. *retracta* may be considered a partially reversionary change, in view of the fact that the extremely crinkled seg. *contracta* had replaced in similar manner the very slightly crinkled seg.

decipiens. A full test of the *erythrina* plants in this family is contemplated for next year. I anticipate that they will be found to segregate regularly seg. *retracta* and *erythrina*. The failure of seg. *retracta* to withstand setting to the field demonstrated that it is a much weaker form than the original seg. *decipiens*, which it now seems to represent in this particular progeny of *erythrina*. The *erythrina* plants of this family are indistinguishable, however, from those in families which yield normal seg. *decipiens* and from those that yield seg. *contracta*, or any of the other new mutational segregates.

Oenothera seg. *sublethalis*, seg. nov.

For several years I have had a strain of mut. *erythrina* which has been characterized by the low frequency of occurrence of seg. *decipiens*, and which I have recorded as "non-splitting *erythrina*." The beginning of this strain was made by self-fertilizing an *erythrina* specimen, 35239(98), in one of my *petiolaris*-bearing families in the summer of 1936. The family is recorded in the beginning of Table 1, and the progeny produced by selfing 35239(98) is recorded in Table 2, under the family number 36304. Family 36299 in Table 1 represents the same or a similar strain of "non-splitting *erythrina*," produced by self-fertilizing individual number (90) in family 35239. These two families, 36299 and 36304, had jointly 2 seg. *decipiens* to 174 *erythrina*, the former having in addition 29 seg. *petiolaris*, the latter having no *petiolaris*. All the families descended from these are given in the first half of Table 10, together with these two initial families.

A similar or identical mutational segregation seems to have occurred in an *erythrina* individual 38300(89), for this individual, self-fertilized, produced the descendants entered in the last section of Table 10. In three of these families, 40126, 40127, 40129, there was seen a total of 9 very tiny stiff rosettes practically devoid of chlorophyll, and the same form may have occurred in family 40128, as four plants had died in that family before it was studied on April 4, 1941, only two weeks after the plants had been set from the seedpan to 75 mm pots. This form is denominated seg. *sublethalis* and is seen to offer a rational explanation of "non-splitting *erythrina*," for it seems reasonable to suppose that just as seg. *contracta* and seg. *elongata* have replaced seg. *decipiens* in their respective families, seg. *sublethalis* may have replaced seg. *decipiens* in the three families listed in Table 10.

TABLE 10

PROGENIES FROM SELF-FERTILIZED "NON-SPLITTING" *Oe.* MUT. *erythrina*

Grandparent Number	Parent Number	*Decipiens*	*Erythrina*	Other variants or doubtful
35239	36299	0	89	29*
	36304	2	85	—
36304	37411	1	20	—
	37412	1	20	—
37411	38293	0	56	1
38293	39486	3	35	—
	39487	1	42	—
38300	39530	1	86	3
39530	40126	0	33	4†
	40127	0	8	3†
	40128	0	31	1
	40129	0	9	2†
Totals (12 families)		9	514	

* These were *Oe.* seg. *petiolaris* which were not out of place in this family, since the parent *Oe.* mut. *erythrina* was a sib of *petiolaris*.

† These 9 plants were *Oe.* seg. *sublethalis*.

The few plants of seg. *sublethalis* that have been found have disappeared almost immediately after they were observed, and unless special attention were given to finding them in the seedpan, they could be overlooked very easily, and may have disappeared before the plants were potted. Quite possibly also the seg. *sublethalis* genotype is so ineffective that most of the seeds do not even germinate. The production of a nearly true-breeding *erythrina* in this putative way would make the *erythrina* of this particular strain agree closely with the balanced lethal situation seen in *Oe. Lamarckiana*. The percentage germination in most of these families has been disappointingly low, but this cannot be attributed solely to the elimination of a putative *sublethalis* segregate. This strain merits a more thorough study.

DISCUSSION AND CONCLUSIONS

In reviewing this remarkable series of new mutational segregations from *Oenothera* mut. *erythrina*, it appears that we are dealing with two unique genetical phenomena, (*a*) the replacement of a previously recurring segregated class of individuals by a new recurrent class of segregates so unlike the replaced class that it is illogical to think of the new class as merely a modification of the old class, and (*b*) the addition of a whole new class of repeatable segregates to the previously known and expected classes.

One fact which has greatly facilitated this study and added to the definiteness of the results, has been that most of the new types are so strikingly unlike both *erythrina* and *decipiens* that there have been almost no errors of classification. Such errors have been common in attempts to separate mut. *erythrina* and seg. *decipiens* in the past, but such strikingly unique forms as seg. *petiolaris,* seg. *contracta* and seg. *elongata* can never leave a doubt as to the accuracy of their classification. Among the new forms there have been some errors in separating seg. *retracta* from *erythrina,* and some error might conceivably occur at an early stage of development in separating seg. *cyanea* from mut. *erythrina.* In regard to such errors as have been made in separating these new forms from mut. *erythrina,* it may be pointed out that these were made in the first families in which the given mutational segregates were discovered. More experience may enable an observer to make a more clean-cut separation of these new forms from the type of their parent.

Whatever the exact mechanism which is operating here, we are justified, because of the relative rarity and the relative permanence of the changes, in recognizing the occurrence of such remarkable replacements and additions of whole classes of recurrent segregates, as of mutational nature.

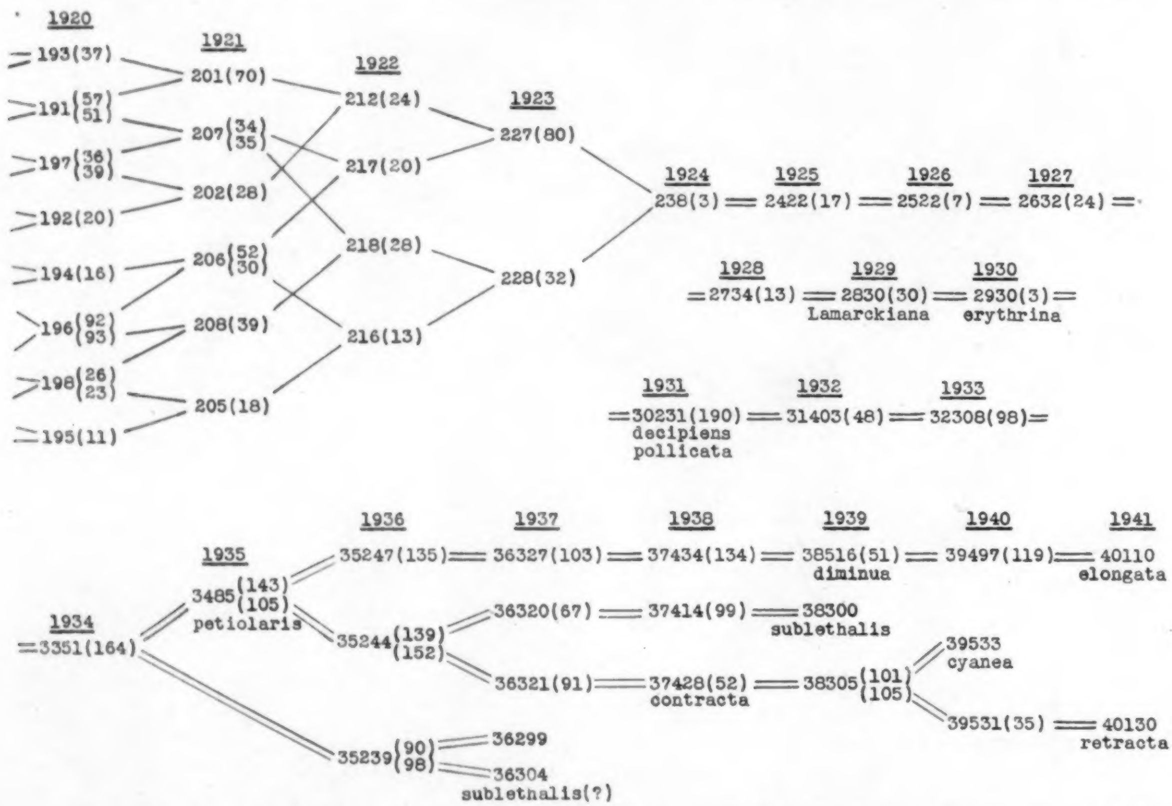

FIG. 27. Pedigree chart for all of the new mutational segregates described in this paper. Double lines indicate self-fertilization. Each number in parenthesis represents a single individual in the family to whose family number it is appended. To the left could be added fourteen additional generations of controlled cross-breeding in the manner indicated by the first generation given in this chart. Previous to 1905, breeding was uncontrolled in a state of nature. All individuals represented on this chart up to and including 2830(30) and all in the fourteen preceding generations of hand-controlled pollination not here included were typical *Oe. Lamarckiana,* and every individual in the chart, including and subsequent to 2930(3), was a typical *Oe.* mut. *erythrina.* The names of the several new mutational segregates are inserted beneath the pedigree numbers of the families in which they severally made their first appearance. The individuals indicated by the numbers in parenthesis appended to these family numbers were *erythrina* sibs of the indicated mutational segregates.

A study of the pedigree records has brought to light the interesting fact that all of these unexpected new segregates have arisen in a single strain of *erythrina*. The pedigree, complete from 1920 to 1941, is shown in Fig. 27. The double lines in this pedigree chart indicate that the parent represented by the preceding pedigree number was self-pollinated. The progenies included in the tables, all of which are descended from individuals whose pedigree numbers appear in the pedigree chart, represent the offspring of a total of 400 selfed *erythrina* plants, and of these not more than 12 produced obvious mutational segregations. This indicates that the frequency of such mutations in this material is of the same general order as that of the more common types of individual mutations, whether chromosomal mutations or gene mutations.

The fact that these mutations have all occurred in a single strain of *erythrina* is not an accident, but is conditioned by the fact that only in this strain has there been such an extensive program of progeny-testing. The question is an intriguing one, whether a similarly extensive series of tests would bring to light a similar frequency of mutational segregations in other *erythrina* lines unconnected with the one involved in the present paper. It is not likely, of course, that any of these same mutated forms would be duplicated in material of another origin, for none of them has been duplicated in my cultures except perhaps in the case of seg. *sublethalis,* which seemed to originate in two different individuals of the same family, and also in another family several generations removed from this. One might suppose that even in this case there is no identity of the three mutations, since the elimination of a class by the presence of a lethal can hardly be assumed to prove the identity of the death-dealing agency in the three cases. Only when it is possible by genetical or cytological analysis to demonstrate that two lethals occupy identical loci is there ground for the assumption that they represent a repeated mutation.

Too little is yet known regarding the mechanism of inheritance in the Oenotheras to allow us even to speak of loci in the ordinary sense except perhaps in the case of the linkages among genes in what I have called the 3rd linkage group, and which are believed to be associated with the paired 1·2/1·2 chromosomes.

There is little basis for a discussion of a putative relationship of the mutational segregations here recorded and the occurrence of segmental interchanges, but it may be conceived that a segmental interchange which should result in associating a *decipiens*-bearing segment in the circle with the chromosome which carries the lethal factor and releasing from such association some other segment characterized by a previously hidden recessive, such as seg. *contracta* or seg. *elongata,* would result in a replacement of seg. *decipiens* by the new segregated group. The "additional" types such as seg. *petiolaris,* seg. *cyanea* and seg. *diminua* present still more difficult problems, but might be assumed to involve an interchange between two chromosomes other than that which carries the *decipiens* genes, thus leaving the relations between seg. *decipiens* and mut. *erythrina* unchanged.

Cleland (1929) has reported that the occurrence of double non-disjunction is a rather frequent type of irregularity in the zigzag arrangement of the chromosomes of *Oe. Lamarckiana,* and the same may well be the case in *Oe.* mut. *erythrina* as well. While this might seem a fairly simple method of transferring a chromosome from one Renner complex or genome to the other, and compensating by removing another chromosome from the second genome to the first, there is a prime obstacle in the way of using this occurrence as a mechanism to explain the peculiar replacement of a well-known type of segregate by a wholly different new type, as recounted in this paper. There is incontestible evidence for the view that every one of the known 14 chromosome-ends is of vital necessity for the existence of a successful individual in the genus Oenothera, but no double non-disjunction is conceivable which would not result in the omission of one or more of these indispensable ends. It seems much more likely that the phenomena presented in this paper represent the genetical consequences of a corresponding number of segmental interchanges, by which portions of chromosomes have been transferred from one genome to another without the omission of any vitally necessary part of the genotype.

Cleland (1942) has recently shown that there are 24 different ways in which mut. *erythrina* can be produced from *Oe. Lamarckiana* by the coincidence of only two segmental interchanges. These possibilities should provide for a considerable number of genetically different biotypes of *erythrina,* but not for the full number of 24 different kinds, since in those cases in which both of the putative interchanges have occurred within the same Renner complex, *velans* or *gaudens,* the gene

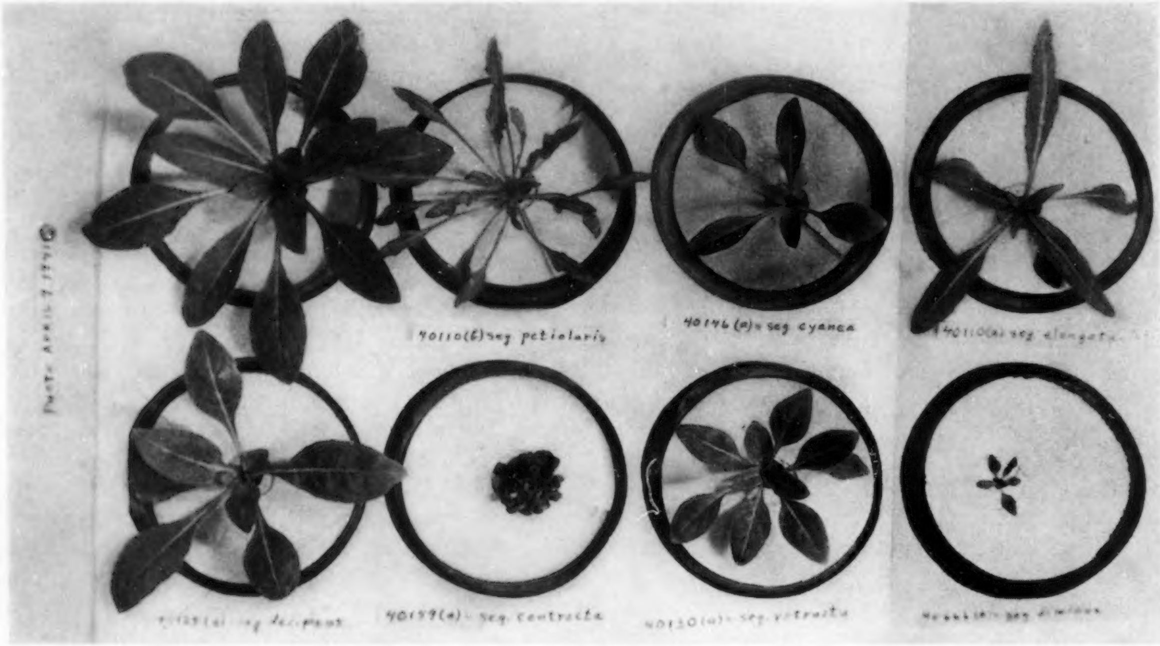

FIG. 28. Recapitulatory photograph of *Oe.* mut. *erythrina,* seg. *decipiens,* and all of the new mutational segregates here described except seg. *sublethalis.* Of the latter the entire rosette could be covered by a single leaf of seg. *diminua.* Photo April 9, 1941.

content of the *erythrina* so produced would remain unchanged. These putatively different biotypes of *Oe.* mut. *erythrina* can have no significance, however, for the genetical phenomena recorded in this paper, for although there are these 24 ways in which *erythrina* might originate from *Oe. Lamarckiana,* the material involved in this paper can have possessed originally only one of these; all are descended by controlled self-fertilizations, from a single original *erythrina* mutant 2930(3), in a line of *Oe. Lamarckiana* which also had been selfed for six years before this mut. *erythrina* appeared (see pedigree chart, Fig. 27).

The new forms produced by mutational segregation in this material offer but limited opportunity for the student of segmental interchange because of the difficulty in getting them to develop to sexual maturity or to be usable for breeding. Thus far, seg. *petiolaris,* seg. *cyanea,* seg. *elongata* and seg. *contracta* have been induced to flower and fruit, but only in small numbers and with considerable difficulty. Seg. *petiolaris* has been found by Catcheside to have a circle of 6 and 4 pairs of chromosomes. Probably seg. *cyanea* will be found to have the same configuration, but whether those forms which are replacing seg. *decipiens* have, like it, an absence of catenation cannot be determined if they do not bloom. A cytological investigation of meiosis in F_1 hybrids between the different individuals of *erythrina* which have unlike segregational derivatives might prove illuminating.

SUMMARY

Oenothera mut. *erythrina,* a well known half-mutant, normally produces a progeny consisting of two types of plants, one of which repeats the parental genotype, *erythrina,* the other a true-breeding type known as seg. *decipiens.* This paper reports the occurrence of seven new mutational segregations from *erythrina,* which are described under the names *petiolaris, contracta, cyanea, diminua, elongata, retracta,* and *sublethalis.* Several others have been observed but not yet adequately studied.

Of these, seg. *contracta,* seg. *elongata,* seg. *sublethalis* and in some cases seg. *diminua* have replaced seg. *decipiens* and seg. *retracta* has replaced seg. *contracta.*

Seg. *petiolaris* has been added to families which had the normal proportions of *erythrina* and seg. *decipiens,* and in like manner seg. *cyanea* has been added to families which had the otherwise normal ratios of *erythrina* and seg. *contracta.*

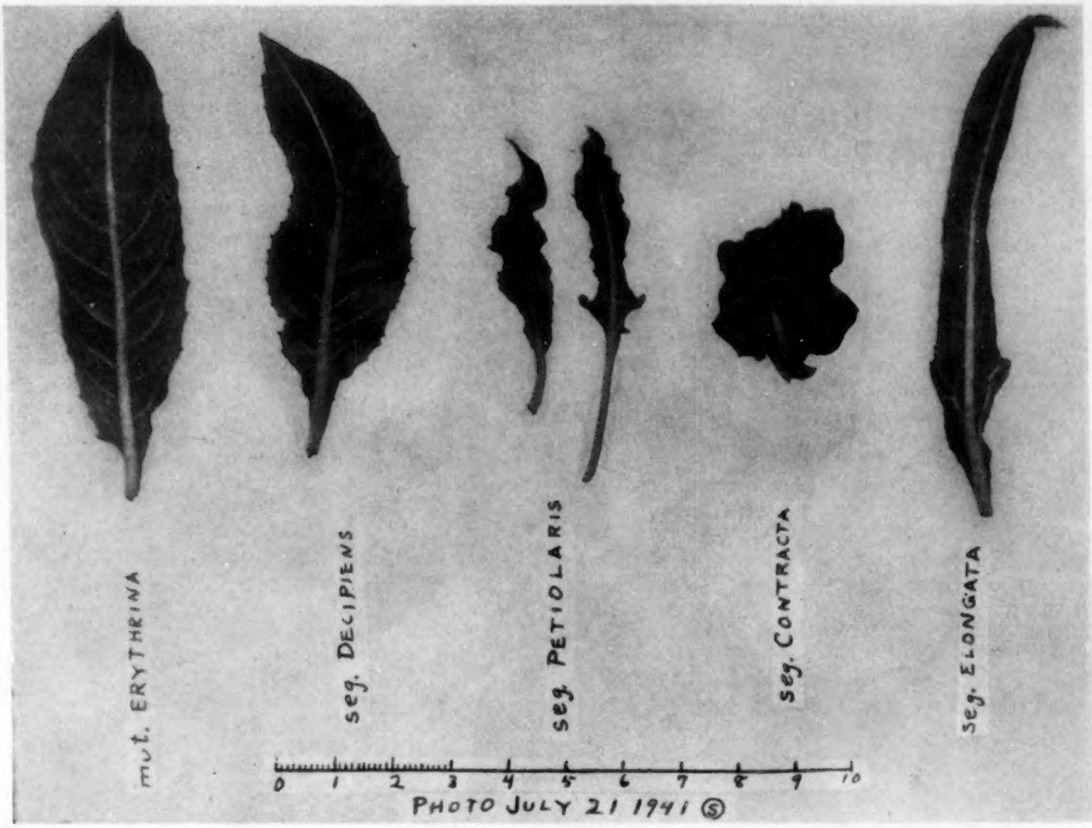

FIG. 29. Stem leaves taken from the central axis about 30 cm above the rosette, for comparison of *Oe.* mut. *erythrina* and four of its mutational segregates, *decipiens, petiolaris, contracta* and *elongata.*

About three-fifths of the *erythrina* plants in a family which contains *petiolaris* will yield seg. *petiolaris* offspring. The rest give progenies containing mainly *erythrina* and seg. *decipiens,* no *petiolaris.*

In like manner about three-fifths of the *erythrina* plants in families containing seg. *cyanea* produce seg. *cyanea* in turn in their offspring, while the remaining two-fifths produce only *erythrina* and seg. *contracta.*

Erythrina plants in families which do not contain seg. *petiolaris,* seg. *cyanea,* or seg. *diminua,* respectively, seem to have lost the power to produce these forms in their progenies.

The replacement of seg. *decipiens* by seg. *sublethalis* has brought about approximately the balanced-lethal condition long recognized in *Oe. Lamarckiana,* thus giving a nearly true-breeding strain of *erythrina.*

All of these new mutational segregations result in plants of inferior physiological vigor, or at least of slower development, but *petiolaris* and *elongata* have come to bloom, in a relatively few cases, naturally in the experimental field but only late in the season. Seg. *petiolaris* and seg. *cyanea* have been successfully brought to maturity in the greenhouse by the application of long-day treatment.

Seg. *contracta* was not induced to flower by means of long-day treatment, but several specimens have produced stems after a summer and winter of partial protection in a coldframe, and have finally produced several flowers.

The difficulty in securing flowers puts obstacles in the way of studies of catenation in these forms but the chromosome arrangement in seg. *petiolaris* has been determined for me by Dr. D. G. Catcheside. The arrangement is the same in this segregate as in *erythrina*—a circle of six and four pairs.

It is tentatively assumed that the replacements of the usual seg. *decipiens* and additions of other new mutational segregations result from segmental interchanges which change the association of the segments involved with respect to a segment containing the putative lethal factor.

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MONTAGNAIS–NASKAPI BANDS AND FAMILY HUNTING DISTRICTS OF THE CENTRAL AND SOUTHEASTERN LABRADOR PENINSULA

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CONTENTS

ABSTRACT

Ethnological material dealing with the hunting territory concepts of the Montagnais-Naskapi Indian bands of the central and southeastern Labrador Peninsula is presented and analyzed in the light of present knowledge of the ecological relationships existing between these people and their faunal and floristic background. The frontier dividing the tundra from the forest is regarded as the factor determining to a considerable extent the practice of communal as opposed to dispersed hunting with its attendant patterns of family ownership of hunting territories. It is further observed that among some groups the two types of hunting system may both be practiced but under different environmental pressures. A sequence of phases in the development of the institution of the family hunting territory is tentatively proposed.

IN a past number of the *American Anthropologist* Speck presented material gathered in the field and compiled, with reports of earlier writers, the material obtained by him through a number of years' investigation of the constituency and territorial locations of some twenty-six local bands of the Montagnais-Naskapi Indians of the Labrador peninsula.[1] In the same article the attempt was made to give some of the social characteristics pertaining to these band subdivisions and to discuss economic features which seemed to influence the social pattern. The material used in the preparation of the article in question included some material that was still unpublished relating to certain bands in the eastern and southeastern regions of the peninsula. The purpose of the present report is, then, to bring out the data concerning the formation of those bands just referred to, giving the details from notes, made from 1922 to 1925, while work was proceeding in the lower St. Lawrence area. In the general article referred to above, reference was made to a series of reports previously published, which presented similar outlines of the bands in other parts of the peninsula. The present material covering the characteristics of the Ste. Marguerite, the Moisie, the Shelter Bay, the Michikamau, the Nichikun, and several other now almost disintegrated groups concludes the collection of material now on hand regarding the boundaries and family composition of the native divisions for this immense region.

The purpose in bringing out the material is to make available the long-shelved notes on the bands investigated over fifteen years ago as a contribution to our knowledge of the social framework of Algonkian peoples of the higher latitudes. Half a generation has elapsed since these data were recorded and inevitable changes have occurred in the bands.

A curious circumstance of the field work which produced the material offered in the study lay in the fact that the investigation of geographical ethnography was carried on before the region under consideration had been mapped. It was accordingly upon the geographical knowledge retained in the memory of the Indians and their ability to demonstrate it on the inadequate charts only available at the time, that the demarkations of hunting grounds were based. Several examples of the cartographic faculties of the hunters as made with pencil were obtained. They are reproduced in Figs. 1 and 2. For the limited areas which they cover they show details of surface of land and water the like of which will

[1] Vol. 33, No. 4, October-December, 1931, pp. 557–600.

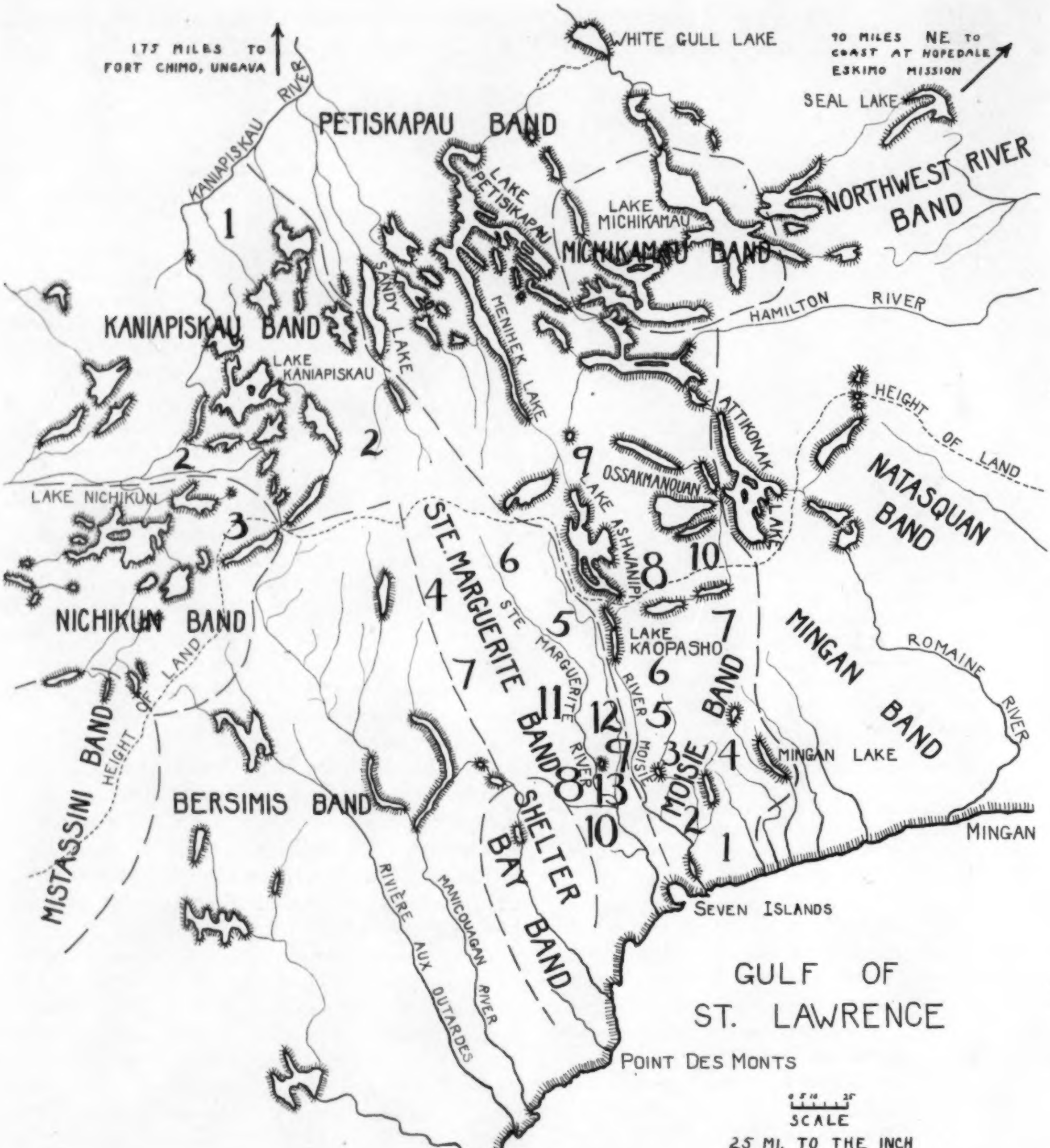

Chart showing distribution of Montagnais-Naskapi Bands of the Lower St. Lawrence and Labrador Peninsula, with approximate location (in numbers) of Family Hunting and Trapping Districts (1922–25). (Drawn by F. Staniford Speck.)

FIG. 1. Sketch map of Pien Andre's winter camp on *Kamacko'gan cakhi'gan* (lake) at head of branch of Ashwanipi River (near Petisikapau Lake) during mid-season separation period (1924–5). Drawn by himself.

Explanation.—At *A*, Andre's two-fire wigwam of caribou skin, his headquarters. The dots around the islands and along shore denote sets of fish-hooks under ice; 4 below the nearest island, 6 on north side of same island, 8 on far side of other island and along shore.

Division of Labor.—One man takes care of each set of hooks, three in all. Two men take road to mountains on northeast of big lake and go to lake system (upper right) for caribou. When wind blows too hard on this circuit to permit returning by same way over mountains, they turn southward to lake marked by fishing sets (dots on lake at lower right) and strike overland and across ice on big lake directly to headquarters camp *A*.

The continuous lines represent the routes taken by the men who tend the fishing and the trails of the hunters on land and ice.

not be indicated on printed maps for a long while to come.

In this cartographic interest the Montagnais-Naskapi seem to vie with the Eskimo. Their ability to represent the lake and river features of their own hunting districts as well as of more distant waterways and portages is a definite acquisition of their culture. Explorers of the Labradorean plateau have noted the accuracy of travel charts drawn upon sheets of birch-bark with charred wood from the days of Napolean Comeau and A. P. Low, down to the observations of Belanger and others, who availed themselves of the plottings to find a way in hitherto uncharted areas. The cartographic faculty has another bearing here upon our quest for details of the background of native land knowledge. It brings out the fact that geographic nomenclature is also a well-developed element of the hunting existence from one end of the sub-arctic forest civilization to the other. In recording the locations and tracts of hunting and trapping among the bands treated here, the names of most bodies of water were given by the men as known to them in their peregrinations. Some of the names entered are to be found in French or English orthography on the published charts available. Others, however, are apparently the names of lakes known only to the native habitués of the more remote regions. These have caused some vagueness in the delineation of band as well as family endroits. Undoubtedly corrections will later be made in the boundary indications given on the map accompanying the report when a more detailed geographical check-up shall have been made. The name listings in the present report will, however, serve as an indication of the familiarity possessed by the men, not only with the terrain itself but also with the unwritten literary nomenclature of their extensive ranges.

Reverting for a moment to the general field of inquiry, we may point out that in the social-economic systems of practically all the Algonkian-speaking peoples so far investigated (inhabiting the area between latitudes forty-five degrees and fifty-two degrees, between the Atlantic and Lake Winnipeg chiefly north of the Great Lakes and within the drainage of the lower St. Lawrence), the recently much-discussed institution of pre-

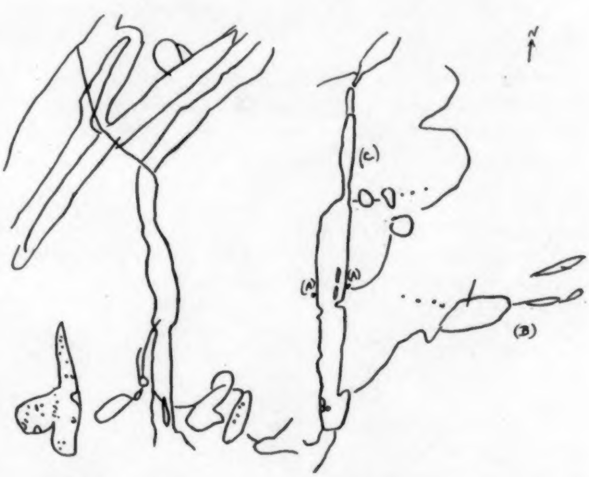

FIG. 2. Sketch map of districts hunted and trapped by Alexander Mackenzie's party, between Menihek and Petisikapau lakes, and on Petisikapau River during winter operations (1924–5). Drawn by himself. Lower left *Katsagwunəkajo* lake (dots denote islands), left center Petisikapau River, right center *Ketceməteo pitcuan* Lake.

Explanation.—*A*, Alexander Mackenzie's headquarters camp, two divisions. *B*, at right and upper right center, location of marten trapping areas. Dots on land areas denote winter trails.

ëmpted paternally inherited family hunting territories has been observed. It does not occur in a single case in eastern North America among other than Algonkian tribes except where alien native culture has been in contact with them and may be suspected accordingly to have been modified in this direction by them. An instance of this is to be noted among the Iroquois who consistently fail to show possession of the trait except in the case of the Iroquois of Oka, P. Q., where it has been introduced through territorial adjacency and social association, even cohabitation, with Algonkian peoples.[2] At the same time we find that the hunting institutions of the Algonkian north of the fifty-second latitude undergo a change from the aspect of affairs that we encounter in the heavily forested region nearer to the St. Lawrence and the Great Lakes. In the latter area the local bands are found subdivided into small family groupings that hunt by themselves throughout the winter, while in the former zone the family groups remain together forming the "large family" bands with more communal hunting customs than those just south of them.

The bands to be treated in this article include both types, and therefore some discussion will be included as to the meaning and possible history of this modification in social pattern of two purely hunting types of society whose other institutions and history seem to be practically identical in derivation. Before indulging in extended speculation as to what causes may have induced the separation of the types and what circumstances may have encouraged their development along one line or another, the substance of information on the make-up of the central and southeastern bands may be considered.

As our understanding of theoretical circumstances involved in the formation and subsequent trend of growth of these bands gets better, so too the collections of pertinent data will improve, and we shall acquire study material out of which should emerge some conceptions of their history superior to those now achievable. Dr. Hallowell's recent ideas, after consideration of cross-cousin marriage practices, actual and implied in the north, and the taking of geneologies, with his testing of matrilocal tendencies in the cohesion of families, exemplifies the kind of progress being made in our approach to an under-

[2] Horace T. Martin in his work on the Canadian beaver entitled *Castorologia* (Montreal 1892) makes a tantalizing reference to a portion of the old beaver hunting territory of the Six Nations lying between Lake Champlain and the St. Lawrence. He speaks as follows (p. 140): "In some cases in the interior of our country, near the height of land, these hunting grounds are still recognized as the rightful property of certain Indian families, and curiously, the line of descent is on the mother's side, so that travellers relate how many an old decrepit squaw is honored and propitiated for favors from her beaver reserve. These reserves were held with as much exclusiveness as a freehold estate in England, and to trespass or to poach on them meant to jeopardize one's life. The question of ownership involved all the mystic relations of the social career of the Indian geneologies, tribal affinities, questions of taste and preference, but also rested greatly in the first instance on the right of might. . . ."

This area, at the time of the French and Indian wars was, from a cultural standpoint, mixed Iroquois and Algonkian. It was really St. Francis Abenaki country—and the St. Francis Abenaki were largely influenced in culture during the historic period by the Mohawk. We have no direct evidence, however, that they adopted a maternal clan system, which would, of course, have placed mother right ahead of father right in respect to land.

Martin, who was not an ethnologist, may have been led into making the statement quoted above through a perfectly natural mistake. Among the northern Algonkian widows were title-holders to hunting land and so were often sought as wives by men who thereby got a hunting estate. Widows advanced in age are often married by young men for such a reason. This superficial observation could easily lead to interpretations involving matrilineal descent of the territories. It must be reiterated that we know of no other instance of *regular* descent on the mother's side though women may have potential claims upon a father's hunting territory should they have to resort to it to avoid famine in case a husband's tract should fail to yield sustenance for a year or so.

The senior writer's observations at Seven Islands are perhaps typical of the variation in practice which is observable even among the Algonkian. Speck found it possible to induce several of the hunters to discuss what they regard as a normal method of procedure in transmitting the use of their territories from one generation to the next. In recording the data on family history and control of the districts in family succession among the bands who make rendezvous at Seven Islands, a generalized statement was made which represents the sum-up of custom among these hunters. It seems that a hunter who works a certain tract of territory will say that he continues to occupy it by right derived from his father in most cases. Some of them reside with and work trapping and hunting grounds with the wife's father—patrilocal association. This affiliation arises when a hunter has no sons to receive the legacy of usu-fruct from his line. "His daughter brings her husband to join the father-in-law's family," was the customary response. Women and children thus had an option in living with either the father's or mother's family, according to the social opportunities offered by each, plus the need for their labor coöperation, and especially determined by the prospects of abundance of the food and fur resources of the lands on one or the other side of the family.

standing of the forces at work in moulding social structure among the northern Algonkian.[3]

Our conclusions will show the established truth of the assumption suggested in several previous articles that there are two types of social development at work among the northern Algonkian, associated evidently with their occupation of one or the other geographical zone types, the taiga or the tundra of the Labrador peninsula and the lower St. Lawrence and Hudson Bay area. Of the two types one is nomadic and communal in structure as regards the grouping of biological family units to form a collective band. It occupies the open tundra north of the forest zone where the Barren Ground caribou is an economic mainstay. The second type is based upon the more sedentary limited nomadic family principle and seems to remain confined to the coniferous forest area. The factor operating chiefly to determine the two is, we believe, traceable in large degree to the natural history of the game animals which alone furnish the natives of the Labradorean area with their subsistence. The governing factors may be recognized as lying within the influence of the seasonal changes affecting the movements of flesh-yielding and fur-bearing animals with its attendant stress and famine circumstances. Both types prevail in the social program of the same band at different seasons, that is, the collective family horde breaks up into the small-family group hunting as a biological unit within a limited often paternally inherited district, or vice versa. This is known as an actual fact from direct contemporary information and from printed statements of French and English authors who first encountered these famine-bred cultures of the subarctic.[4] The point deserves more weight in our study of the subject as investigation proceeds. Caron is one whose remarks are clear-cut and definitive enough to merit reference.[5] Alluding to the bands on the upper St. Maurice (the Têtes de Boule) he observes: "Mais la famine augmentant sans cesse, it fallut en venir à se séparer, en effet, par petites troupes les sauvages avaient pliés la chasse de résister à la famine, et si une troupe mourait de faim, et de misère, on pourait espérer que les autres seraient épargnées." ("But famine increasing without check it became necessary for them to separate. Accordingly, in small companies the Indians pursued the chase to avoid starvation, and should one company die of famine or of misfortune, it could be hoped that the others would be spared.")

Reference to the two modes of hunting just discussed is manifest in the remarks of Davies[6] who also knew the Montagnais-Naskapi well:

"Depending solely on the chase for a subsistence, they of course, lead an erratic life, following the deer[7] in their migrations from place to place; keeping generally together in large camps, a circumstance that frequently subjects them to the extremes of starvation; the game being soon destroyed, or driven to a distance from them—in this respect they differ from their neighbors the mountaineer Indians, who seldom or ever hunt together in large numbers, two families generally associating themselves for that purpose. . . . They are extremely liberal toward each other; whatever the hunter brings to camp is shared without reserve, in equal proportions among the whole community—this custom is not peculiar to them however, they possess it in common with all Indians who live by the chase. They are not fur hunters, nor is the mode of life they lead favorable to it; the chase of the deer leads them to the barren parts of the country, while the fur-bearing animals are only to be found in the woods; moreover, their favourite occupation furnishes them with all they require—they clothe themselves with deerskins—their tents are made of the same material, as well as their nets. . . . Their number is but small, 40 or 50 families comprise the total of those frequenting the posts of Ungava Bay."

In the preceding statements the habit observed among the northern and eastern bands of the

[3] The several grants of the Faculty Research Fund of the University of Pennsylvania from 1931 to 1933 have made it possible for Dr. A. I. Hallowell to carry out his expeditions in the field among Cree and Saulteaux, and for Speck to add to his earlier field notes obtained from the Montagnais of Lake St. John and surrounding bands accessible through them. Again in 1935 another grant (no. 286) by the same committee made possible a return to the bands of the southeastern coast as far as Eskimo River in the Straits of Belle Isle. Additions were then made to the material previously collected.

[4] This point has been approached in several previous statements, and Dr. D. S. Davidson has also used the same line of view.

[5] Abbé N. Caron, "Deux Voyages sur le St. Maurice." Trois-Riviéres, 1887–8, p. 128.

[6] Davies, W. H. A., "Notes on Ungava Bay," *Transactions of Literary and Historical Society of Quebec*, Vol. IV, pt. II, 1854, pp. 129–131.

[7] By "deer" Davies means caribou.

Montagnais-Naskapi, of starting the fall migration into the interior hunting grounds in a group hunting communally is brought out in clear terms. These bands remain in this type of social formation as long as game conditions permit, that is to say as long as the caribou can be followed and killed in sufficient quantity to support them. Should the caribou fail them, however, they are obliged to separate into small parties to save their lives and fall back upon the hunting of small game wherever they can find it for the remainder of the season. This means that they break up into family units comprising the man of the family, his wife, children and such dependents as he may have. The family group of this designation may also include his son or sons and their wives, or his daughters and their husbands, according to whether their residence is patrilocal or matrilocal. The latter circumstance raises a point of no little importance in the history of band affiliation among the northern tribes, one which Dr. Hallowell is weighing out in its bearing, likewise, upon marriage procedure.

It seems conclusive from the data at hand, then, that stress-conditions govern the breaking up of the communally hunting band into family units. And stress-conditions arise through the movements of the game. Thus the ruling element in the problems the natives of the northern districts have to face is the success or failure of the hunt for the Barren Ground caribou.

Matters are quite different in the economic circumstances of the bands of the southern and western portions of the Montagnais-Naskapi habitat, where the hunting environment is that of the forest, where game is more diversified and more abundant though smaller in size, and scattered through the forests. And here furthermore the moose enters into the economic system while the caribou is of the woodland race which runs in smaller numbers.

In the environment of the northern bands the struggle for existence is intensified by absence of forest, causing a less thorough dispersion of the game and a difference in its type. We hardly need attempt to outline the effect of the forest-covered hills mountains and swamps upon the life of animals and their distribution over territory, as contrasted with the conditions prevailing in the thinly forested or treeless tundra farther north. The animal life of the open regions is wide-ranging and mobile.[8] Hence the northern bands hunt in a horde formation, as do the wolves, in pursuit of the caribou which travel in hordes and upon which they depend so largely. The frontier dividing the tundra from the forest, to be concise, is the factor determining the character of animal life and the social-economic life of the Indians within and without these respective zones.

The question of change and decline in population of the bands under consideration, and in fact those of the Labrador Peninsula at large, has engaged the attention of statisticians of population, government officials, missionaries, traders and the Indians themselves for a long time. Speck commented upon some of the figures available from several earlier and later sources in a paper to which reference has previously been made. Taking the collective estimates of the population of the bands under consideration in this report, we have a total of 300 souls listed for Seven Islands in 1857, while the census of Indians in Canada of 1924 gave 380 for the same agency. The matter has much deeper implications than the mere question of survival, in the relationship between mortality among the natives, the rise and fall of populations in the different bands and the still little-known periodic cycles of abundance of animals; the so-called seven-year "plagues" affecting the animal population of the northern regions.

Seton and others have drawn attention to these problems. Elton, in a work which deserves the careful attention of anthropologists, gives considerable space to faunal fluctuation and migration in the Labradorean area.[9] He shows how an increase of mice, or even mosquitoes may affect, sometimes through a long chain of events, the movements of caribou, and hence the fortunes of man. He maintains that "there is hardly a single fur-bearing animal in Canada that does not fluctuate in numbers from year to year in a most striking way." [10]

Burt, in a recent paper,[11] makes some valuable

[8] Even the herbivores of the forest zone may not constitute an entirely static and reliable quantity. J. R. Dymond, for example, indicates that both the white-tailed deer and moose may absent themselves from considerable areas over long periods of time, and then again return. See J. R. Dymond and L. Snyder, "The Faunal Investigation of Lake Nipigon Region, Ontario," *Transactions of the Royal Canadian Institute*, Vol. 16, 1928, p. 247.

[9] Elton, Charles, *Animal Ecology and Evolution*, Oxford Press, London, 1930, pp. 18–23, 30–31, 40–42, 78. See also Murphy, R. C., "Conservation and Scientific Forecast," *Science*, n.s. Vol. 93, pp. 605–607, 1941.

[10] Ibid, p. 18–19.

[11] Burt, Wm. H., "Territorial Behavior and Populations of Some Small Mammals in Southern Michigan," *Miscel-*

observations on the size of the home range of certain of the smaller northern mammals, as well as pointing out many gaps in our knowledge of territorial range, particularly among the larger forms. He makes it clear, however, that the smaller fur-bearers are very limited in their range of movement under normal circumstances. The size of the area occupied by an animal is necessarily limited by the creature's ability to travel and its needs in terms of food and protection. Predators will tend to range more extensively. A rodent, ever in danger from enemies, must be thoroughly familiar with the area over which it ranges in order to survive. In Burt's own words "Animals that are moving about in search of a place to claim as their own are covering unfamiliar territory and are much more vulnerable . . . than are those in established territories."

Having noted these observations of Elton and Burt let us consider them in terms of their possible influence upon the hunting pattern of man. Elton has considered the tremendous fluctuation in numbers and area of movement of some of the northern animals. The significance of this to a hunting people is tremendous. In the course of his discussion Elton makes one statement of profound interest to the ethnologist: namely, *that the beaver is almost the sole northern fur-bearing animal the numbers of which have not been observed to fluctuate with the unsteady cyclic variability to be found among other northern forms of life.* The beaver, it must be remembered, was food long before he represented other forms of wealth. It now seems evident from these biological observations that he was a most reliable and steady source as well.

Consider further the comments of Burt upon the relatively small range of the rodents in general. The beaver has little chance to survive among fierce and powerful predators, such as the lynx and glutton, unless deep water is available as a retreat. They are thus, in the words of another zoölogist, "restricted to the water courses, reveal their presence by unmistakable signs, and build domiciles such as their lodges, which, though not furnishing exact information as to the number inhabiting them, are at least conspicuous indicators of family establishments. . . ." [12]

laneous Publications, Museum of Zoölogy, University of Michigan, No. 45, May 8, 1940.

[12] Johnson, Charles E., "The Beaver in the Adirondacks: Its Economics and Natural History," *Roosevelt Wild Life Bulletin*, Syracuse University Publications, Vol. 4, No. 4, 1927, p. 576.

In other words, as the writers maintained in a previous paper,[13] an animal of great significance economically, even before white contact, is seen to be one the habits of which make it easily located even under arduous winter conditions, the range of which is limited, the stable home habits of which make it possible to husband by restraint in killing, and the need of proper stream conditions of which again foster a limitation of sites sufficient under scarcity to place a premium upon assured family ownership. Moreover, such an animal, dependent to a major extent upon aspen bark [14] is preëminently a creature of the forest and not the tundra zone. When its seeming freedom from cyclic instability is taken into account its human importance is accentuated. We are greatly in need, however, of a more detailed knowledge of the animal and human interrelationships of the whole Canadian region.[15] An approach to this aspect of the dove-tailing cycles of human and animal fluctuations in number will be a future step in the method of treatment of the economic problems of the area, under ecological methods.

Later, when the present collections of data shall have become records of a faded past era, we shall have to use them as we now use material placed on record, scanty as it may be, by investigators whose labors date back twenty years or more. The collections of matter offered in the pages to follow are accordingly enhanced by a time perspective now of almost a generation of age, since they represent conditions prevailing in family and band history between 1915 and 1925. Had we a record of affairs in these groups characteristic of the period say about 1900 and again

[13] F. G. Speck and L. C. Eiseley, "Significance of Hunting Territory Systems of the Algonkian in Social Theory," *American Anthropologist*, Vol. 41, No. 2, April–June, 1939, pp. 269–280. Most recently Hunt (G. T. Hunt, *The Wars of the Iroquois*, University of Wisconsin Press, Madison, 1940) emphasizes the influences of the fur trade, especially the beaver trade, in causing aggressions of the Iroquois into the territories of the Algonkian.

[14] Warren, Edward R., *The Beaver*, monograph, American Society of Mammalogists, Williams & Wilkins, Baltimore, 1927, p. 17.

[15] Klugh, A. B., and McDougall, E. G., "The Faunal Areas of Canada," *Handbook of Canada*, University of Toronto Press, 1924, p. 202. "The difficulty of dealing with the faunal areas of Canada is greatly increased by the fact that data on the distribution of the animal life of the dominion is, as yet, very incomplete. There is not a single locality the whole fauna of which is known."

of 1880, the time perspective so much needed to demonstrate the change processes of the hunting societies could be visioned. Our first era of ethnological observation, however, must begin with that described here. The next is about now due after a lapse of nearly a generation of hunters' lives. It is then a happy thought that the material of the accompanying report concludes nothing, but on the other hand begins something which is now ripe to be reharvested by newer and better understanding and method.

Former Coast Divisions

That there was in former times a more or less permanent population resident on the immediate coast of the St. Lawrence is clearly shown in the early accounts. These refer to Tadousac and Seven Islands as centers of the Montagnais contacts from 1673 onward. We learn of this from numerous sources. In a letter attributed to a missionary of the Saguenay in 1720 appears the statement that Tadousac has been for a long time the gathering place for all the Indian natives of the north and the east.[16] Crépieul (1673–4), the Jesuit, gives a report on the natives of Seven Islands and Tadousac which were then centers of congregation for the coast Indians and those who emerged to trade and associate with their kind from the interior.

These groups, if they ever possessed an independent character, separate from their relatives who migrated annually from the hinterland then as they do now, have left no indication of their social composition lasting down to the present. Perhaps if they were originally band units they have in the course of time become entirely fused with the larger migrant bands, the former coast-dwellers from Tadousac to Seven Islands. The natives themselves are aware of the two populations, one holding to the coast, the other dwelling in the interior. These are respectively denoted *notci·mi·wilnu'ts*, "people of the interior," and *wi·ni·pe'gwilnu'ts*, "people of the salt-water." In another paper, comment has been offered upon the significance of these terms.[17]

A casual observer could well imagine the coast-dwelling populations to enjoy economic advantages superior to those of the inland hunters, assuming that the more abundant resources of the bays and gulf would provide a richer subsistence. This does not, however, seem to be the case. Any of the coast "mêtis," of the "petite chasse," would exchange his "job" for the life and fare of the "gros chasseur" of the far bush. He invariably does so when his vigor and fortitude secure for him an offer from a big hunter in need of a partner. For the "mêtis" it would mean escape from the precarious employment of a small sphere to the freedom, the adventure and possible greater profit of furs of the big woods. The coastal natives are by-and-large the "petites gens," the physically incapacitated, the near-bankrupt, the lazy, the indigent, the timid. One might also imagine the coastal families to claim prestige through their assimilation of white mores. But they could not assume it in the presence of the interior hunters. Prestige lies with the latter, socially and financially, as observed by Speck between 1915 and 1925.

Without pretending to solve the question presented by the confusion of testimony on the earlier history of these long-dissolved band groupings, it is now evident that the two bands, Ste. Marguerite and Moisie, which hunt and trap over the territories in question, have become amalgamated. Some of the details referring to the earlier natives of the coast districts will be taken up under the headings which treat of these two groups.

It is true at the present time that a strip of country bordering the Gulf is not regularly inhabited or worked for its fur and meat by any specific family tenants. According to the lay of the coast, its rock exposure, and scarcity of wood, the distances of the worked hunting ground may be as much as forty to fifty miles inland. For the most part these stretches are exploited for what natural resources they may yield by certain families which remain permanently in the neighborhood of the trading posts and fishing settlements. Most of them are of mixed blood. Their connections, along both social and occupational lines are with the posts. Routine follows the callings of the coast. In summer off-shore fishing in boats, filling various capacities in affairs between the posts and the hunters from the interior with their booty of furs when the exodus to the coast is on, taking employment from the settlers also to fill in time, in the fall hunting and netting seals, in the winter taking small game and fur wherever it can be found

[16] Rapport des Missions du Diocèse de Québec 1864, pp. 21–2, see A. E. Jones, S. J., *Mission du Saguenay*, Relation Inédite du R. P. Pierre Laure, S. J. 1720 à 1730, Documents Rare ou Inédites, Montreal, 1889, pp. 4–5. Also Jesuit Relations, vols. 54, 63 and 65.

[17] F. G. Speck, "Montagnais-Naskapi Bands and Early Eskimo Distribution in the Labrador Peninsula," American Anthropologist, Vol. 33, No. 5, 1931, p. 580.

pieced out again with employment from the posts, in the spring fowling and sealing until fishing opens up. We are at a loss to conclude the extent to which these pursuits would coincide with the economic cycle of an aboriginal population in their direct line of ancestry. It is possible that from early times there were subdivisions of the "Montagnais" who consistently clung to the coast in contradistinction to their higher-altitude-loving kindred, the so-called "Naskapi" of the hinterland. Yet one has the feeling all the while that their conditions have been considerably moulded by association with Europeans since the early establishment of the French fishing stations. Certain it is that assimilation with inhabitants of the latter has progressed to a degree necessary to be given full weight in the story of composition of the coasters.

Localities along the coast are, however, well known even by those whose permanent homes are strictly inland. The islands forming the Seven Islands group are enumerated by Sylvestre Mackenzie, chief of the Michikamau band and elected head man of the aggregation of groups at Seven Islands (1925). They were given as follows:

Kaictəbo′ ministu′k, "Big Island," Grosse Boule.
Acini·′uts′wap ministu′k, "Stone House Island," [18] Grande Basque.
Kawaba′pickats ministu′k, "White Rock Island."
Backwɔ′ ministu′k, "Basque Island," Grande Basque.
Mənawani·′s, "Little Island," Manowin.

In view of what has been said regarding the unassigned coastal zone, a section representing this strip has been left unmarked by boundaries of the bands when shown on the chart. It would also represent the recession of the Indians who live by hunting from the coastal margin of the peninsula, due to the disappearance of the game there resulting from the establishment of French-Canadian fishing stations at the mouths of rivers. In this connection the following faunal references from the Jesuit Relations [19] are of interest:

The first is a memorandum for a missionary to be sent to Seven Islands:

"He will find there next spring at various times about 150 persons, both adults and children. He will probably see all these—and perhaps others who come from the interior or *from the shore of the sea*." (Italics ours.)

"The entire coast is of frightful aspect. There is not even the space of a drying ground of soil; it is all rocks, covered with very small trees of spruce and fir;—save the little birch, not one beautiful tree. There is no end to game, all marine birds. . . ."

"All along the coast, seals are to be seen, upon which the savages live during the entire summer."

Hind also yields interesting material on the coast division:

"When leaving the coast for the interior, many families have particular rivers to go up by, and often in a large body; but once a certain distance inland, the whole party break up and disperse into bands of two and three families each to pass the winter, and seldom see each other any more until spring; but before taking their final leave of each other a place is appointed to meet, and he or they who first arrive at the prescribed rendezvous (if having sufficient food to wait) keep about the vicinity until the whole party collect; they then go to fetch their canoes, wherever left when the cold sets in, and employ themselves, some in making new canoes others in repairing the old ones, until such time as the ice breaks up in the large lakes, and the waters subside in the rivers; they then move off in a fleet of canoes towards the sea, and generally make their appearance at the coast about the latter end of June." [20]

The fact that the location of these bands in the seventeenth century lay at the frontier of distribution of the Eskimo westward in the peninsula gives them a tinge of importance. While at present we do not know what the force of this circumstance may have been upon both groups it is, nevertheless, a circumstance to be borne in mind. A series of sources available for this distribution terminus of Eskimo has been collected and cited in the article quoted previously and to which we would now refer again.[21] Another extract from Hind (1853) which bears directly upon the Indians of the Moisie and their tranditional conflicts with Eskimo presents material worth quoting:

[18] The informant stated that a stone house had once been built here by the government, whence the name.

[19] *The Jesuit Relations*, Thwaites edition, 1899, Vol. 59 pp. 57–59.

[20] Hind, H. Y., *Explorations in the Labrador Peninsula*, Vol. II, 1853, p. 121, quoting a Wm. Chisholm who lived for forty years among the Montagnais as a factor of the Hudson's Bay Company.

[21] Speck, *op. cit.*, 1931, pp. 564–71.

"The mouth of the Moisie or Mis-te-shipu' River—the 'Great River' of the Montagnais Indians—enters the Gulf of St. Lawrence in longitude 66° 10', about eighteen miles east of the Bay of Seven Islands, and has its source in some of the lakes and swamps of the high table land of Eastern Canada. For centuries it has been one of the leading lines of communication from the interior to the coast, traveled by the Montagnais during the time when they were a numerous and powerful people, capable of assembling upwards of 'a thousand warriors' to repel the invasion of the Esquimaux, who were accustomed to hunt for a few weeks during the summer months a short distance up the rivers east of the Moisie, as they do now on the Coppermine, Anderson's and Mackenzie's Rivers, in the country of the Hare Indians and the Loucheux. The old and well-worn portage paths, round falls and rapids and over precipitous mountains on the Upper Moisie, testify to the antiquity of the route, independently of the traditions of the Indians who now hunt on this river and on the table land to which it is the highway.[22]

Moisie and Petisikapau Bands

There is some evidence to show that at a former period the families who dwelt in the region of Petisikapau Lake constituted a group about as well defined socially and economically as the other family consolidations which have been classified as bands by both Indians and whites. Through changes affecting the composition of the older units of the remote interior in the century past it seems that the Petisikapau horde has suffered a fate similar to that of the Kaniapiskau and Nichikun people recently, and which is overtaking the Michikamau group at the time of writing. The disintegration of the band has thrown its members into the population complex to the southward, nearer the shore-folk who make rendezvous at the Seven Islands post. Since the hunters from the Petisikapau endroits descend by way of Moisie River and associate with the people deriving their identity from the Moisie, they have become considerably fused and intermarried with this group. The Moisie Band derives its name from the river of the same name, which denotes its muddiness. The native proper name is, however, *Mictaci·'pu*, "Big River."

The Indian family names of the preceding generations have been superceded. French surnames of the families which operate territories on the lower Moisie River indicate what has transpired in their history; extensive intermarriage with the French-Canadians of Côte du Nord, as the north shore of the St. Lawrence is politically and geographically designated.[23] Most of them show the mixture in some degree. They are bilingual for the most part. Some of the younger men will take employment, when it is possible, with the traders, prospectors, hunters, and lumber concerns, temporarily, as a form of economic relief if not of progress in the way of civilization.

Concerning the location and ethnic constitution of the Moisie Band, we quote from Speck: [24]

"Like the Ste. Marguerite band, the Moisie people seem to be of mixed extraction so far as original units are concerned. The families who operate nearer the coast may be the residue of a population of former times which belonged south of the Height of Land, and the northern families of those belonging in the interior. Whatever may be the explanation of the somewhat confused condition of affairs now it is fairly certain, from native sources of information, that it has not undergone extensive change within the last two generations. The families falling under this band classification number ten, and hunt and trap the territory up Moisie River and east of it to Mingan and Attikonak lakes, from the coast to the headwaters of Hamilton River beyond the Height of Land.[25] Also like the Ste. Marguerite Indians the majority of the families operate south of the divide, have smaller hunting grounds, and observe more closely the family system. The northern families seem to have connections with the limited nomads of the interior lake country whose populations have in

[22] Hind, H. Y., *op. cit.*, Vol. I, pp. 9–10.

[23] Photographs of nearly all the adults of the group were made and the films are filed in the collections of the Museum of the American Indian (Heye Foundation, N. Y.).

[24] *Op. cit.*, pp. 584–585.

[25] These districts were located on the chart published in 1913 by Gustave Rinfret, Departement des Terres et Forets, Quebec, 1913, by finger of the men of the band who gathered to contribute to the investigation. Inexactitude was inevitable. Yet on the whole it was apparent to Speck that these hunters were not conscious of boundaries to any degree comparable with the land division sense of members of other bands investigated by him in regions where the limitations, both geographical and social, were more closely observed in native life. This condition was apparently due to a less distinct pattern of land proprietorship in the area of the eastern Montagnais-Naskapi. The marginal situation of these groups from the point of view of the communal versus segregated family methods of pursuit would seem to be a part of the question.

recent years become so dispersed. Upon the closing of the Hudson Bay Company's post at the mouth of Moisie River the band transferred its summer mission and trading center to Seven Islands. It has now (since 1915) no separate chief.

"In Hind's time (1861) the hunters from Ashwanipi Lake were referred to as the 'Aswanipi' band, which he says was dispersed in the nineteenth century to the north and east. This lake is now hunted by families which come under the name of the Moisie group who may have pushed northward since that time."

Speck's investigations yield the following data on the ten families, previously referred to, who make up the Moisie band:

1. Ange Picard hunts and traps in a small way from the falls of Moisie River upward for about 40 miles on both sides of the Moisie. The district is an unproductive one, from which the great game has been banished by increase in the coastal populations. With him as partner is Joseph Vollant, who has recently been so seriously disabled by an injury that he is an object of local charity. Both have mixed families of young children.

2. Philip and Tommy Moise (brothers), also Moise Vollant, use trapping grounds on both sides of Moisie River for about 30 miles above the forks of Moisie. These families are of mixed Indian and French extraction. Owing to conditions of sickness in the band at the time when their members were contacted the desired details of family make-up were not obtained.

3. Bernard Pinette operates in a territory beginning about 40 miles above the forks. His father, Bastian Pinette, from whom he takes his land, is now too old to hunt, and stays at the village of Moisie.

4. Magloire Regis has a location on Manitou River extending to Mingan Lake, some thirty miles inland, and east of the family heads thus far listed in this band. Magloire is brother to the ex-chief, George Regis (No. 5) of the Moisie band. In this direction we have an approach to the people of the Mingan Band. The latter has not been made an object of attention so far in the contemporary survey of the peninsula. We have no data on the composition of the family.

5. George and Delphis Regis (brothers) pursue their trapping and hunting each winter on both shores of Moisie River about 60 miles from the mouth. Information is lacking concerning their children. George Regis held the office of elective chief of the Moisie Band prior to 1922, representing the combined populations of the Indians from various bands assembling at Seven Islands. He was succeeded by Joseph Vachon (No. 10, Ste. Marguerite Band).

6. Johnny, Joseph, Charles, and George Vollant, brothers, cooperate in trapping and winter residence over a tract lying about the foot of Kaopasho Lake (*kaopa'co*, "narrow passage in middle") and headwaters of the Moisie, northeast branch. The informants who indicated their holdings on the chart included a lake to the northeast just below the Height of Land as an extension of their working area. This tract was inherited from their father, old Malek Vollant, who is now too old to make the peregrinations to and from the interior to the coast. He stays at the Seven Islands post.

7. John Marie Rock (*Djama'ni*, Indianized from the Christian names) and his son of the same name with wife, comprise a two-hunter partnership in a fairly large district about the Height of Land east of Kaopasho. Mamickau ("northeast") is the lake near their geographical center. It might be thought that the name Rock is a translation of *A'cini·* "rock," a family name among the St. Augustin Indians far to the eastward on the Gulf, but it is not so considered, being ascribed, rather, to French origin (Rocque).

8. Charles Pilo's sons, Mili', François, and Sylvestre, congregate upon grounds lying at the head of Kaopasho Lake, on both sides, and northward into Ashwanipi Lake territory a little across the Height of Land, according to their indications on the work map used in the listing. No further information was recorded of their families. They held possession of the region from their father Charles, and trap in subdivisions of the grounds agreed to among themselves.

9. François Jérome and his dependents comprise the family group which winters on the north (lower) sides of Ashwanipi Lake. Further information is wanting.

10. Tommy Vollant, a member of the family of the same name (No. 6) localized on lower Kaopasho Lake, has extended his hunting and trapping routes to the northeast beyond the Height of Land covering the watershed of a series of large lakes around and west of Attikonak and Ossakmanouan lakes. These vast and barren stretches of plateau desert demand mobile habits of their human dwellers and closer boundary determinations are impossible to consider. We are led to conclude that the populations here live

and move more in a concourse than those of more abundant natural zones.

The families of Moisie classification so far enumerated are less restricted in their manner of hunting and trapping than those to the southwest toward Lake St. John, for instance. The scarcity of edible large game animals, the devastation of the region by annual bush fires, not to mention the growing encroachment of Canadian-French trappers in the European drift northward to exploit new areas, is having a destructive effect upon their game resources. Reactions upon the human inhabitants, who for so long have lived in relative equi-balance in these deserts, have been noteworthily destructive in the long run.

Petisikapau

The Petisikapau people, who, as we have already observed, have disappeared as a major and geographically independent group into the limbo of association with the Moisie Indians, derive their name from the lake of their ancient location, Petisika'pau. The term *pe'təsəga'pao* defines a body of water "narrowed in the middle," which seems admirably appropriate for its shore contour. The lake is noteworthy for having been the location of an early interior trading post, Fort Nascaupee of the Hudson's Bay Company founded in 1840, for commerce with the remote bands of the hinterland.

"The information upon which this and the following band are classified is extremely little," Speck records.[26] "There seems," he says, "to be an area of several hundred miles, according to Low, with a very sparse population. And from testimony obtained from natives at Seven Islands his claim is borne out, although a few of them from these endroits, east of Lake Michikamau north to the Kaniapiskau River, gave their identity as Petisikapau people and were so recognized by the others. My listing assigns six family heads to this group. I would not, however, insist upon separate classification as a band for these families, although they are listed as such for the present. The vagrancy of the hunters of this central region is a noteworthy feature of their lives, to which we may add the decrease of its population as causes contributing to the uncertain identity of its few remaining families. Both of these bands, if such they are, pursue the winter hunt for meat and caribou in collective groups. Hind refers in several places to 'Naskapi' from this lake and mentions a Petisikapau band of fourteen families, which has induced me to consider its classification as a band unit of the past if hardly one of the present.

"By the Indians at Seven Islands the name *Məne'yik wilnu'ts*, 'white spruce people,' is also applied to the inhabitants of Menihek Lake, a branch of Petisikapau, though I do not know how to discriminate between the two as band names. Were the records of old Fort Nascaupee, founded on Lake Petisikapau in 1840 and long since abandoned, available, some light might be thrown upon the affiliations of the natives by tracing their family names."

That the Indians constituting the Petisikapau band of former times have, since the time of Hind (1861), also become assimilated with those who then constituted the populations nearer the coast at Seven Islands is indicated by Hind's notes. He stated that the Petisikapau band then comprised 14 families.[27] We could not (1922–5) designate the few families who winter as far in the interior as the said lake under the caption of a distinct Petisikapau band apart from their coresidence and intermarriage with the coastal units about Seven Islands. A similar dissolution has been the fate of the band which Hind informs us to have been formerly located at Ashwanipi Lake but dispersed to the north and east in the 19th century, and which he designates as the "Aswanipi" Indians. The judgment of the hunters with whom the matter was discussed at Seven Islands was that the old Ashwanipi units had merged with coastal branches into the Moisie band. As such they will be considered in another section of this paper.

These observations concerning the remote families who winter in the high lake districts of the remote interior plateau are to be taken as founded upon the testimony vouchsafed by the heads of the same name-families with whom the matter was discussed at Seven Islands and checked with the statements of Henry Hind who sojourned with them eighty years ago. As our information stands it seems that the absorption of the interior bands into the coastal populations began with the movement of the Ashwanipi horde in the mid 19th century, joining with others to form the Moisie Band of later times, followed by the merging of the Petisikapau and Kaniapiskau families with these of the Ste. Marguerite Band, and lastly the dispersion of the Nichikun people to join temporarily with the

[26] Speck, *op. cit.*, p. 590.

[27] Hind, *op. cit.*, Vol. 1, p. 82.

general populations of the coast at Seven Islands. The Michikamau group it seems has withstood the tendency to break up better than the others.

As testimony of movements of this nature, we have mention by Hind [28] of a Naskapi hunter named Paytabais who had starved to death in the interior about 1857. This man, we are told, lived about old "Fort Nascopie." At the present time a man named Petabesh (*Peta'bec*) comes down to the Seven Islands post with the families from far inland, whether from Petisikapau or Michikamau it was not ascertained positively. It is likely that he carries the family surname first noted by Hind.

Old Napes Gregoine (*Gne'gwen*, Indianized French, Grégoire) and his son Napes, represent a family for which the information obtained was very unsatisfactory and confused. The upper environs of Menihek Lake down northward to Petisikapau, and embracing the area of *wutce'goci·pu*, "otter river" (unlocated on the charts) were given by several men of this name as the ancestral domains. The family was evidently dominant in the Petisikapau group of almost a century ago, having since merged with the Ste. Marguerite band in part. (See Ste. Marguerite, Nos. 5 and 6.)

Nabesh Gregwenish (*Gnegweni·'c*, "Little Gregwen") was given by informants as the hereditary hunter and trapper of a large area on lower Menihek and Petisikapau lakes. He is married to a daughter of Sylvestre Mackenzie, head man of the Michikamau group, and is closely associated with his father-in-law. No specific data on the family composition of these men were secured.

It should be noted here that the families who were centralized about Menihek Lake bore a distinctive name, if they lacked a separate classification, among the Indians at Seven Islands. The name *Məne'yik wilnu'ts* (or *i·nu't'*) "white spruce people," was current, derived from the lake in question. It was not, however, thought to be specific enough to classify them as forming a distinct band, for which reason, at the time, their little understood associations were left open. Disintegration of the older interior hordes has left a chaos of identity in the subsequent groupings of these families.

Michéle Ambroise and his son Joseph, about 20 years old, hunted the environs of Petisikapau Lake from the shores northeast for a distance of some 70 miles. Since Michéle's death within the last few years his widow and son continue the work. Hind (1863) [29] mentions a hunter from the interior as Ambrosis, who held grounds at that time, about Nipisis Lake (Moisie Band No. 3), a body of water lying not more than about 60 miles inland from the coast. Ambrosis answers to a diminutive form of the name Ambroise, yet there is little more to identify these men as of one line of the same family in view of the distance separating the hunting grounds noted for them.

Louis Michéle. The records of the Moisie hunters include him as working a territory on Moisie river, aided by a young man, Pierre Dominique, 20 years old. But no further data on the relationships of these men are at hand.

Ste. Marguerite and Kaniaspiskau Bands

The Ste. Marguerite River is on one of the large and important streams draining the south central slopes of the peninsula and emptying into the Gulf of St. Lawrence a few miles west of Seven Islands Bay. It is called *Tcema`n·bi·ctuk*, meaning "River Parallel with Hills." The band that is allocated upon its waters bears the name *Tcema`n bi·ctı ʀwilnu'ts'*, "River Parallel with Hills People." The band seems to have been one of old formation for we have mention of some of the families in Hind's narrative.[30] The ten families at the present time forming this group contain some old patronyms. A few notes concerning its habits will serve to bring out some characteristics.

Seven Islands Bay has been continuously the summer rendezvous of the band, in fact its exclusive resort until the movement began a generation ago for the hunters of the Moisie band to move over and spend part of their summer period with the Ste. Marguerite people. Even now the social monopoly of the Seven Islands trading post and mission rests in the hands of the Ste. Marguerite Indians. One part of the village is their quarter, the other houses remaining vacant until the families from Moisie have come to occupy them as they do late in July, during the last two weeks of the mission held annually for the natives of the combined bands of this section of the coast.

A very close connection exists between the Ste. Marguerite Indians and the Kaniapiskau families immediately north of them. There

[28] Hind, *op. cit.*, Vol. I, p. 15.

[29] Hind, *op. cit.*, Vol. I, p. 188.

[30] Hind, *op. cit.*, Vol. I, p. 11 gives the same name (Ichimanipistuk) for the Ste. Marguérite in 1861.

would, indeed, be little reason to separate them were it not for their habit of using different local names for their groups and for the rather vague geographical boundaries that separate them.

These two divisions may possibly turn out to be divisions in name only when more is known of their former history. It would be necessary to know, for such a decision, just where the grandfather of the present elder generation of the Tcelnish families had his location in the interior. At this present period of time, the three family units of the name draw their sustenance from hunting districts far beyond the height of land in the Lake Kaniapiskau region, while only one having the Tcelnic patronym (*i.e.*, Alexandre) hunts south of the divide. It might be thought that a century ago the hunting would have been better nearer the St. Lawrence coast; hence a withdrawal of the old families toward the interior plateau with the retreat of the game in the same direction. This circumstance would, however, apply chiefly to the caribou. If we were to seek to connect the earlier story of the Tcelnic family name with similar patronyms elsewhere in the Naskapi territories we should be led afar since the same name occurs in several directions among the bands as far west, for instance, as Lake St. John.

Hind who knew this band fairly well in 1861, says that the first migration of the families from the interior to Seven Islands was two years before his visit there, bringing it in 1859.[31] He mentions the family name of Tcelnic (Chelneesh), and Otelne as being those of interior or proper Naskapi derivation.

Things have not changed so much in regard to location of bands and their movements in assembling at the Seven Islands post and mission since Hind's time (1861). The Ste. Marguerite band, which he referred to as Montagnais, then being as sharply defined from those he called Naskapi inhabiting the Moisie as far as Ashwanipi and Petisikapau as they are now.

The Kaniapiskau people are known among their confreres by the name of the lake (*Kaniapiskau*, "Rocky point"), which has for many generations been the pivotal center of their winter wanderings. A few notations we possess concerning them specifically may be summarized from the report of Speck in 1931:[32]

"The identity of this band, like that of the preceding, is known only on the authority of hunters from the region who were encountered and questioned upon the occasion of their annual migration to the post at Seven Islands. When questioned as to their affiliations they used the name given above, but it does not seem that there is much political consciousness to the few who answered to the classification. Low refers to Indians trading at Nichikun post who hunt about Kaniapiskau and down its discharge about fifty miles, but speaks of uninhabited areas between here and the western boundaries of the Indians from the Northwest River, and another such on both sides of Koksoak River from the Nichikun territories to where those of the Ungava hunters begin."

Again, investigations by Speck furnish data concerning members of the band:

1. Sylvestre Tcelnish hunts with his son Bastian. Bastian had six or seven children in all—two little boys between 8 and 12, a girl about 17, the rest younger. Since by his own declaration he had "too many mouths to feed" through hunting alone, he (Sylvestre) lured Tommy Jourdain to help him feed his family. Tommy, although a "son of a bitch of a good hunter" is a consumptive, but it is expected that he will marry Bastian's daughter. Tommy is a grandson of old Charles Jourdain. The men themselves furnished the data on this tract, the most northerly of which Speck obtained data. It lies northwest of Lake Kaniapiskau down Kaniapiskau River to Big Otter River to within about 50 miles of the big bend of the river and 200 miles from Fort Chimo.

2. Pierre (also Pielis) Tcelnish (*micenate'o*, "great approacher of game") is the last of his paternal line, and is related to the family mentioned above. He hunts with his son, Shimun Piel (Simon Peter), about 16, who does a man's work on the hunt and trap line with his father. They hunt the environs of *Pəckwute'o cakhi'gən*, "fire lake," and *Gawace'gəmət*. These waters lie southeast of Kaniapiskau Lake, and also just west of the lake, lying about 300 miles up the river from Seven Islands.

3. John Pierre (originally of the Ungava Band) married a daughter of Sylvestre Tcelnish, now hunts on grounds formerly held by Otelne, now deceased. (This territory was possibly allotted due to circumstances of family No. 1. It has not been inherited.)

4. Alexandre Tcelnish hunts with two grown sons, one married and one with a child. His grounds extend westward from Ste. Marguerite

[31] Hind, Vol. I, p. 4.
[32] Speck, *op. cit.*, pp. 590–591.

River at Riviére à la Bataille (about 51° 40′) and Portage de Manicouagan (which is the route to Manicouagan River some 60 miles distant about 40 miles west, *i.e.* over half way to Lake Tschimanicouagan on the Manicouagan.

5. Napeo Gregoire (Gnegwen), 40 years old, with two sons and two daughters, hunts between Ste. Marguerite River and Lake Aswanipi. This hunter and his family bear a low reputation among the men of the band for violating the credit allowances made by the post factor in advance of the winter hunt. The practice is deplored by the other members of the group as damaging the interests of them all in financial transactions with the factor. The older generation of this family is listed with the group or band wintering in the distant territories of Petisikapau and Michikamau lakes. The family surname may be identified with these far northern hordes. The confusion of first names and family names in the Gregoire line leaves us in a position which becomes most difficult to clear up.

6. François Gregoire and his two sons, Nabeo (married, with no children as yet) and Antoine (24 years old) hunt west of Ashwanipi lake and south of the Height of Land working the environs of two lakes still unmarked on the charts available, namely Chibougamou and Wabushkatso ("hare excrement"). Their next neighbor on the north was stated to be Nabesh Gregoire, a close relative. (The synonymy of family and personal names here again causes considerable confusion of identity.)

7. Tomah (Tamas) Otelne, "Tongue," is an old man 60 years of age, disabled through the loss of an eye, and retired from active hunting and trapping. He and his brother Nisham Tomah (Otelne) who died about 1923 (at the age of about 50) hunted together through life a tract on Manicouagan river (*mənikwa'gənictu'k*) about 60 miles long and 40 wide on both sides. It required about a month's travel, he stated, to reach the endroits from Seven Islands. He and his brother hunted the same territory worked by their father, and they thought the same held in the paternal line for generations back. He had had no daughters but four sons, with only one—Nabes Otelne—surviving, who operated with him until his death (1923). Nabes was known as a famous hunter by the factors of the Seven Islands Hudson's Bay Company Post. Philip (aged 21, and just married at the time these data were secured in 1923) will succeed to the paternal hunting district from now on, taking up his first regular hunt in this year. This terminates the male lineage of a famous and estimable line of hunters who had operated the same territory in male succession for at least four generations.

The character and personality as well as the hunting endroits of a Naskapi named Otelne are made the subject of some treatment by Hind. He leaves us in a difficulty, however, to explain the present hunting locations of the family to the westward of Ste. Marguerite river when he noted the location of Otelne in his time (1861) as being on Aswanipi (Ashwanipi) Lake.[33] Change of residence of later hunters of the Otelne lineage may be imagined to account for this through marriage and matrilocal shift. He also mentions another, Akaske ("Arrow," *akəsk*), whose name, however, was not so far as we know, transmitted as a surname in any of the regional bands.

Small Hunters

A categorical classification prevails in the ranks of the Indians who make their summer rendezvous at the Seven Islands post, between the great "illustrious" men who lead their lives in the far remote plateau and those of lesser fortitude and station who hunt and trap on the lower course of the Ste. Marguerite and Moisie rivers and tributaries. Among the traders the first ranking is designated the "big hunters", the second the "little hunters", or irregular men, since they frequently change their hunting districts by common arrangement. In this verbal distinction—there being nothing official in its application—we may recognize what has long been understood among the Indians themselves as constituting the divisions of the *notcimi·wilnu'ts*, "interior or remote forest people" (also known as *pi't'*, "inside") and the *winipe'gwilnu'ts*, "salt-water, or coast, people." The latter are, moreover, now to a large extent mixed with French blood and assimilated in habits and properties with the Canadian *habitants*. Hence the lower esteem in which they are held. In the list to follow is given the series of those families so classified by informants at the post.

It is patently evident that the stage of the "little hunters" represents a later phase in the history of society and economy among the bands of the region considered here. This example of change with sequence should, however, be handled with caution in any overt attempt to apply it as a broadside for interpretation of his-

[33] Hind, *op. cit.*, Vol. 1, p. 248.

torical conditions among other bands. The hunting territory institution may as well have developed into the communal band type of economy as out of it if we take single instances of one or the other as the definite case for the whole area of Montagnais-Naskapi occupation.

8. Johnny Pilo, a mixed blood, about whose family composition information is lacking, has locations west of Ste. Marguerite River, about 80 to 100 miles north of Seven Islands. His family derivation was given as of the Moisie Band where others of the surname are listed. Whether however, his privilege is accounted for by marriage with Ste. Marguerite Indians, or by assignment through tribal or post authority was not ascertained. The tract he operates, as given, is from Rivière Vallée north about 35 miles to R. Gamache, and 25 to 40 miles back from Ste. Marguerite river.

9. Charles Jourdain, 75 years old, now retired from active hunting and trapping, had four sons and one daughter. Three sons are now living and hunt upon the same paternally inherited territory which old Charles Jourdain says his father and grandfather used before him. This provides another case of three or four generation occupancy of the same territory and continuance in the paternal line with patrilocal residence of married couples. The three sons, filial partners, are Teddy, Alexandre and Antoine. Antoine has recently married the daughter of his father's brother, an example of parallel-cousin mating. For this "privilege" he is obliged to pay a penalty to the priest at Seven Islands out of his next year's fur catch. The Jourdain territory lies east of Ste. Marguerite River northward from about Grande Portage and Lac au Poëlon to about R. Athanase, a stretch of about 25 miles, between Ste. Marguerite River and the northwest branch of Moisie River.

10. Joseph Vachon, nicknamed *Wacaucoje'p*, "Bay Joseph," works a territory adjoining the mouth of Ste. Marguerite from Seven Islands bay westward, and just back of the coast, to where the Shelter Bay families come down. His adjacency to the bay has earned the sobriquet. The tract is hardly more than 25 miles in breadth and is unproductive except for small game.

Vachon has held the nominal office of Chief of the Indians congregating at the Seven Islands post from a period dating around 1915 down to the time when these investigations were made (1925). He is consequently the official representative of the Ste. Marguerite and Moisie bands in matters relating to the Province. His authority is, however, insignificant, and is not recognized by Sylvestre Mackenzie, the head man of the families who come down from the remote plateau, *i.e.*, from Michikamau.

11. George Fontaine, a young man with several immature children, ascends the Ste. Marguerite to a location on its west bank north of the territory of Johnny Pilo, and works the country westward some 25 miles, stopping where Rivière à la Bataille comes in to mark his district from that of Alexandre Chelnish. Fontaine is a mixed blood who divides his efforts between trapping and working when opportunity comes at the Seven Islands post.

12. Joseph Oshogan (*oco'gən*, "hip bone"), concerning whose family composition no data were obtained, operated a district between the Ste. Marguerite and the northwest branch of Moisie river, 10 to 20 miles in depth, from about Rivière Athanase to near R. aux Pins, some 25 miles.

13. Joseph Fontaine, who bears the nickname *Mui'yak*, "Eider duck," and, as our data indicate, his brother François Fontaine (*Wucəpi'pi'*, "gall"), have a location on the east and west sides of Ste. Marguerite beginning a little below R. Dumais and R. Vallée, and extending north about to Lac au Poëlon. The Fontaines are small hunters and operate a small tract of some 15 miles of non-productive country largely depleted of its animal life. We have little to offer regarding their family which rates as French mixed-bloods.

It is worth noting in respect to preferred custom that the Ste. Marguerite hunters agreed, when the matter was opened for general discussion among them after the separate men and their families had been questioned, that some habitual principles were held to in the division of hunting and trapping land. The father of a family who has sons coming into activity will let the boys hunt one section while he does another. They plan to meet together only about once a month, during the course of the winter. Their working stock comprises between 200 and 300 traps. Exceptions are admitted in the arrangement when occasions arise to make readjustment expedient in the family economy. The meat and fur supply is not secured by the use of rifles to as great an extent as might be thought, for it happens that the Ste. Marguerite hunters in 1924 ordered only six new rifles for the following year's business. They now use 303 Ross-Lee-

Enfields, having changed from Winchester 40-4 for which they do not now care. Muzzle loaders are, however, kept in the winter camps as reserve weapons in case of emergency resulting from breakage of the more complicated machinery of the modern pieces which they are unable to repair.

Felony on the Hunting Grounds

A fair picture of the conduct of the Ste. Marguerite hunters could not be drawn without referring to statements made by certain of them concerning the unethical tendencies of members of the Fontaine families to "pull traps," *i.e.* to remove the contents of others' sets and possess themselves surreptitiously of the pelts within reach. A similar complaint was registered for some of the Jourdain family, though to a lesser degree. There was no hesitation among those who made these disclosures in mentioning such facts. Otherwise the irregularities cited were stated to be practically unknown in the conduct of the combined bands throughout the zone of their operations. The proper procedure for hunters in passing through the territory of others is to skin any animal found in the traps of the local proprietor and carry it until a time when they meet and it can be given to the owner of the traps and the trap line. An instance of the kind —reprehensible in the eyes of the men—was cited during the past winter when Alphonse St. Onge of the Ste. Marguerite group passed through the land of Joseph Mackenzie of the Moisie band, and found two martens there which he brought down to the post and sold.

It is most important in this connection to have a statement from the men themselves pertaining to their own beliefs as to what is the factor in restraint upon the petty larcenies of which they accuse certain of their band comrades, particularly in view of the circumstance that no violence is on record as a result of such misdemeanor. Neither is there reference in the discussions invited from their lips, to action by the so-called superior authority of the "chief." The only answer evoked from various sources was the explanation, given in the manner of a bated obvious result, that a spell of bad luck would ensue. The quality of fear is present and trespass has become imbued with a feeling of lurking menace from conjurational sources if not the supernatural resentment of the animals themselves to cause vague misfortune, sickness, game depletion, accident, or some other of the nameless dreads menacing their existence without let, to add to the trials of life. Approach to the question was much the same in response; nobody wished to be explicit as to the form of spiritual persecution that might follow. They seemed to understand this vagueness and expected Speck as well as others of a questioning mind to do so. Equally important was the conclusion that no retaliation either social or physical was ever enacted. No one, for instance, presumed that a hunter whose traps had been lifted would perpetrate a similar act of stealth upon his offenders. A generalized fear of a spiritual avalanche of bad fortune settled the repeated attempts to sound the reasons for ethical self-control in the matters of property rights in the forest domains.

The remarks just made apply to all the bands dealt with in this report. It might be interesting to add that in the vernacular of the traders who are most familiar with aberrations of this type, and who, indeed, occasionally see fit to rectify them over the counter, designate the prohibiting force as the fear of "hoodoo."

The evidence we have here of a protective force, spiritualistic in character, carrying a menace of retribution hovering over the family food-producing districts, is significant of deeper implications in regard to the history of land-tenure beliefs. It conveys a sense of basic originality, it would seem, for the land institution with which the religious concept dovetails. Could we discern more instances of practices fitting into the religious system of belief, a clearer idea of their age-place might be forthcoming. It will mean something in the understanding of the history of hunting territory institutions if a more extensive series of practices accumulate in our records to ground them in religious thought which we are accustomed to associate with antiquity.

In addition to the heads of families previously listed as big and little hunters, there are some half- and quarter-bloods who hunt irregularly over the country near the coast wherever they can find fur and flesh from season to season without being recognized as having preëmpted rights or any other form of claim to holdings. From the point of view of the interior hunters, they constitute a proletarian class and are considered more as Whites than Indians. Their occupations are varied; small hunting, trapping, intermittent labor for the Canadians of the coast, and guiding sportsmen in the hunting and fishing seasons. They are derived from the older families through second and third, or more, generation mixture with the French *habitants*, having for the most part French surnames. And they reside permanently in houses in the village of Seven Islands in a quarter at the north end of the single long lane, following the shore of the bay, which forms the main street of the settlement. Batiste Picard, *Nabeoco'*, "Old Man," is one of the type who resides at the post, does odd jobs thereabout, interprets, mends canoes and on occasion makes a small trapping excursion into the bush to relieve matters. His sons hire out to explorers, sportsmen and to other Indians who need help in their territories and pay on shares. His brother Ange Picard, however, casually operates a small and depleted district on the lower Moisie (Moisie, No. 1) and consequently is listed with the Moisie band.

Shelter Bay Band

In 1925 the status of the several family groups comprising the Shelter Bay Band was very difficult to settle in regard to relationships and earlier history. The individuals comprising the band were almost completely merged with the general population of the combined offspring of the earlier more distinct divisions that now assemble annually at Seven Islands. The Shelter Bay individuals are all much mixed with French blood. Three families represent them:

a. Tcibäs St. Onge
b. Francis St. Onge
c. Malekis Vollant

That something of a separate identity has either remained from a former grouping or been developed since the days of intense trapping and trading with the Hudson's Bay Company and with the infiltration of alien blood may be shown in the name *Wəsakwopəta (a'n) wi'lnut'*, "People of the Portage," which has come to be locally assigned to them by other Indians. This name is derived from that of the river *Wasa'kwopata'gən ci'bu'*, interpreted as "Mossy Portage River", upon the waters of which they travel and hunt inland for about 100 miles. The St. Onge family claimed to have occupied this tract since the time at least of the grandfather of Tcibäs, who was approaching seventy years of age. Tcibäs St. Onge was the father of Francis. The latter was married, had a large family of children, and resided on the waters of the same river, having received a partition of the paternal district. The father of Tcibäs St. Onge was Dominique St. Onge whose age at the time of his death was above ninety. This man had the distinction of being mentioned by H. Y. Hind, previously referred to. Hind had considerable to do with the then young Dominique who, when Speck met him in 1913 was still active despite his age and living with his wife. He told Speck that he had had eleven sons of whom two only were living. His father, he asserted, was a Micmac from Gaspe, who had located on the north shore of the St. Lawrence and married a Montagnais-Naskapi woman, hunting the same territory that he had. There is, in consequence, some uncertainty as to the original content of this small band. It is probable that the mother of Dominique, the oldest of whom we have definite knowledge, may have been the inheritor of the Shelter Bay region which has since passed down through the male line to its 1925 holders. The other family head of the band, Malekis Vollant, was married to one of the St. Onge women, so here we have a case of matrilocal affiliation. The Vollant family, as noted, is properly attached to the Moisie Band. The Shelter Bay hunters on account of their nearness to the Seven Islands rendezvous spend much time at the post. They leave in November, come out from their hunting grounds once during the winter, arriving about January first, and leave again in February to stay in the bush until March. The distance from salt water is about 60 miles. There seems little more to note concerning the history and habits of this small band. It has no distinctive traits, and is evidently to be considered as one of rather recent foundation.

It should be noted, perhaps, that Speck found testimony to show that Tcibäs St. Onge and Malekis Vollant have moved from former hunting grounds on the lower Ste. Marguerite river to their present locations on Shelter Bay river. The statement is evidently more applicable to Malekis Vollant, since we know that his father (Malek V.) was affiliated with the people in the neighborhood of Seven Islands bay, and that they now are members of the same line in the Moisie Band. The three hunters and their wives, a brother of Francis, the five children of Francis, and one son and two daughters of Malekis, made a total of some fifteen members of this gathering. Three of the hunters had adopted patrilocal residence and two of them matrilocal residence at the time of inquiry (1925).

Nichikun Band

The Nichikun band has been dissolved as a social unit since the abandonment of the Hudson

Bay's Company at Lake Nichikun circa 1919. The band is indeed an old one, being indicated upon charts of the 17th century in the same location that we find it now. Some particulars were given in the article in the *American Anthropologist* referred to already.[34]

Members of this band were met with during several periods when Speck was working at Seven Islands in 1915 and 1925. Following the dispersion of the families of the band, he was told that some took up their residence with the Moisie Indians while others joined the bands west of them. The only mention of the Nichikun band that bears the mark of definite attention upon specific circumstances of this band is that of A. P. Low (1895), which is as follows: [35]

"These Indians belong to the western Nascaupee tribe. They speak a dialect closely resembling that of the Montagnais. The men are of medium height and fairly good physique. Some are tall and well developed, but the average height does not exceed five feet seven inches. Like other Indians they are sinewy rather than muscular. As a rule they are less cleanly than the Montagnais, taking little care of their clothes or persons; and they generally swarm with vermin. Owing to the small numbers of caribou killed in this region, the natives are forced to clothe themselves in garments bought from the Hudson's Bay Company. They live in wigwams covered with cotton, as they cannot get either the deer skin used in the north or the birch bark covering of the south."

"The hunting grounds of the Indians of Nichikun extend from the Height of Land on the southward, to the headwaters of the Great Whale River on the north. To the eastward they hunt as far as Lake Kaniapiskau and down its discharge about fifty miles. . . . The greatest number hunt to the westward of Nichikun, or about the headwaters and tributaries of the Big and East Main rivers."

"During the summer they subsist almost wholly on fish caught in nets in the lake. . . . During the winter the living is better for then . . . they are able to obtain . . . fresh meat. About a dozen caribou are killed by the people of the post during the year, besides beavers, muskrats and bears. Usually rabbits and ptarmigan are abundant during the winter season and are shot and snared as required. In some years, however, both rabbits and ptarmigan are not plentiful, and caribou are scarce. During such seasons the food supply is very limited, and great care must be taken to avoid starvation. . . .

"There are about thirteen families of Indians who trade at this post, but this does not represent all the people inhabiting this portion of the interior, as a number of families prefer to descend to Ruppert House and trade there. . . . Others living to the southward who formerly traded at Nichikun, now descend the rivers flowing into the Gulf of St. Lawrence."

Hind in referring to the natives who frequented the region about Pletipi Lake, which he says was three days' journey from Lake Mouchualagan inhabited by Montagnais, designates them as Naskapi.[36] It might seem from this that his informants regarded them as associated with the Nichikun who are nearest to them. Until, however, the composition of the populations making their rendezvous at the Bersimis post has been worked out this point will be left open. At the time when these records were made the men of the Nichikun band encountered at Seven Islands were so recently thrown into the newer associations of an alien adjustment that it was difficult to arrive at a clear understanding of the past and present grounds where they worked. They also seemed suspicious.

The list of families of the band at the time of their dispersion is as follows, given me by Joseph and Peter Hester, at Seven Islands:

Tcwa'li (one daughter, two sons)
(This man was chief, holding his authority for life. His father was chief before him.)
Joseph Hester [37] (two sons, one daughter)
(Peter Hester, Kokuc ("Pig")
(Débid (David) Hester, Wapatci·' ("Tomorrow Morning")
(three sons, two daughters) brothers
Alphonse St. Onge [38] (no children)

[34] Speck, *op. cit.*, p. 591.

[35] Low, A. P., "Report on Explorations In the Labrador Peninsula Along the East Main, Koksoak, Hamilton, Manicuagan and Portions of Other Rivers," *Geological Survey of Canada*, Ottawa, 1896, pp. 100–101.

[36] Hind, Vol. 1, pp. 197–200.

[37] Peter and Debid (David) Hester are the sons of old Joseph Hester who came originally from the Rupert House band. Joseph Hester had previously hunted with his father-in-law, Dominique, *Ntəgwənic*, "little medicine." He did not have much success over a period of four years with his affinal father-in-law. Then he returned to his paternally inherited tract in the year 1924. This individual case well illustrates the adventitious character of the hunting arrangement, determined by environmental circumstance rather than an exacting social pattern of behavior.

[38] Alphonse St. Onge (40 years old) son of old Tcibäs

Pieni·′c ("Little Pierre")	(no children)
Pilipi·s ("Little Philip")	(four children)
Nte′bit′	(four children)
William Tcali (son of Tcwali, above)	(four children)
Ayi·′cuk′ʷ (meaning ?)	(no children)

Assuming that the wives of the family heads, listed above, were living, the band would total around 40.

Questioning disclosed the fact that the Nichikun families did not separate and hunt or trap alone on inherited hunting grounds, as do the Montagnais south of them. So far as conditions of the game and season will permit they all hunt together.

Speck was informed by the Hester men that before changing the trading route to the Seven Islands Post, they descended to the Rupert House in six-span canvas canoes. The change at the time of this visit (1910) had effected some striking results in their condition. The hunters listed had married or intermarried with French-speaking Indians trading at Seven Islands, had come under the sway of priests where they had hitherto been adherents of the Church of England and, in addition to their English were using Canadian French with no less fluency than the Seven Island natives.

Michikamau Band

The group now to be considered derives its name from Lake Michikamau and so bears the designation *Micikəmo'i·'nuts*, "Great Lake People." The area of land usage traditionally preëmpted by its members in support of life centers around this immense body of water which lies considerably north of the Height of Land.

The Michikamau horde is apparently the most integrated of the groups living in the central interior of the peninsula. The isolation of their habitat and the recency of their emergence from solitude into the confusing *milieu* of life at the Hudson's Bay Company's post at Seven Islands have tended to preserve their social independence and to fend off the disintegration through mixed marriages and adoption of French-Canadian ideals and manners. Sickness introduced by contact with the coastal populations has also begun to have its effects. The cohesion of the band depending largely upon caribou for food is nevertheless noticeable by contrast with others who hunt in segregated family fashion over a larger part of the year. The authority of its chief, Sylvestre Mackenzie, a leader by nature of his personality, authoritative and practical-minded, is pronounced, and may be a contributing factor to the unification of the horde. The salient data pertaining to this band, given in the report of 1931, from which summaries have been quoted for other bands, may be cited here:[39]

"The environs of Lake Michikamau, chiefly between this lake and Petisikapau, about 100 miles in extent, are embraced within the limits claimed by the hunters who give this name to their group.

"The band has not apparently attracted the attention of previous travelers or writers. Therefore it is upon the testimony of its chief, Sylvestre Mackenzie, and other members that I base my assumption of its existence as a band unit.

"The Michikamau Indians live and hunt almost continually as a community of grouped families. Only when pressed by famine do they separate and live upon small game. At other times it is the caribou that supports them. Under the jurisdiction of the chief, the group comprises thirteen family heads who are practically all related by blood and marriage.

"Until recent years this band went to Northwest River for trading purposes. Now its members in one large company make the long and dangerous descent from their distant lake to the post at Seven Islands by way of Menihek Lake, Ashwanipi Lake, and Moisie River each year."

The migrational cycle of this band to and from its interior domain to the coast at Seven Islands is interesting from the light it sheds on the matter of time and energy spent annually by the human drove in the peregrinations of trade. The chief, Sylvestre Mackenzie, gave Speck the outlines of his travel narrative in 1924. Punctually on August 1st the band leaves "salt water" (Seven Islands) ascending Moisie River, passing through Kaopasho Lake and then across the Height of Land, reaching Menihek Lake by about October

St. Onge, has no children of his own so he has adopted his brother's widow's son, now four years old, to bring up as a future helper. He winters and hunts a territory about 60 miles in diameter around Lake Attikopi Lake, which lies north of Nichikun, and also Eagle river and lake. His route begins about a day's journey by canoe from the former Nichikun Post. This man evidently represents a later distribution of hunters after the dissolving of the Nichikun band proper, since he is of a younger generation than Tcibäs who is a propriteor of the Shelter Bay Band.

[39] Speck, *op. cit.*, pp. 589–590.

5th. Here they camp to fish and hunt for a few days. Thence they move along by easy stages to Michikamau, hunting and fishing and reaching their destination at Michikamau by the end of October. From here they plan to separate into family groups for a season of trapping to accumulate fur. It is essential before this temporary dispersion that they decide upon the place where they are to gather—the first rendezvous of the winter. Sometime in November this takes place. From this time until toward the end of January they travel as a band, depending upon and following the caribou for food. This is the mid-winter hunt. Around the end of January, the great period of casualties should the caribou fail them, they separate again by families to pursue trapping in their habitually frequented tracts. About the end of March or the commencement of April the entire "gang" (a traders' term) comes together again at the customary rendezvous on Menihek Lake. Here an extensive encampment of tented families soon congregates as it has for many generations—incidentally a promising place for stratigraphic archaeological work when opportunity is afforded. From then until the commencement of May the convening of hunters and their families goes on and the horde prepares to descend to the coast with the harvest of fur. Early in May the flotilla gets under way moving southward over the Height of Land, through Ashwanipi Lake and down the Moisie River, arriving at the Moisie post almost punctually on the 25th of June. This completes the cycle of the annual migration from interior to coast. It should be noted that some families as well as individuals, who for various reasons are unable to undertake the trek, remain at the Menihek gathering place over the summer until the return trip of the southbound flotilla is due the first week of October. They subsist chiefly upon fish. A few, we are told, may refrain from the coast migration for many years, some never going down.

It is a matter of judgment to what extent we may conclude that the insistence of fur traders upon increase in the production of skins by the natives had the effect of adding an incentive to the economy of the Indians, obliging them to divide their time on the hunting grounds between hunting for food and trapping for pelts. The division of labor between the two activities as just outlined would seem to be an adjustment to the demands of trade, with pressure from without exerting a stimulus upon trapping as a competitive pursuit with food hunting. Assuming then that the food quest is an inevitable aboriginal occupation and that fur trapping has been accentuated since contact with Europeans, a chronological sequence may be postulated in the case before us. The economic pattern, either communal hunting in a horde or segregated family hunting throughout the entire winter or only part of it, can as well be conceived to fit the character of country and game by one system of pursuit as the other. The trapping activity, however, practically necessitates the separate family distribution of population over a wider area, and intensively in spots where fur-bearing animals abound. The magnitude of the recent change in the economic set-up of the Michikamau Indians is manifest in the fact that they now engage in the more arduous and consuming annual voyage from their hunting grounds to the Seven Island post than the trek to Northwest River as formerly. This procedure is in the endeavor to gain the advantages of better trade at greater expense of time and effort. Trade has become a moving impulse in their life calling. We may accordingly postulate the direction of change in the case of this band by placing the communal caribou hunting activity before the era of trapping in split-up family groups. But to apply the same gauge to every band in the Montagnais-Naskapi complex to prove the postulate would be to cheapen the methods of research by shape-shifting to a degree beyond the bounds of patience. To propose an explanation for economic change over a wide area of the north by assuming that the history of any one band is a recapitulation of the whole would be unjustified. In the theoretical discussion in our conclusion this fact must be carefully borne in mind.

A phase of the habit of preëmpting precincts needed or necessary in the course of their hunting, trapping and traveling reappears in the social actions of the hunters who come out from the interior down to the coast at the Seven Islands post as a usage-right once assumed then transmitted by traditional agreement is yet to be noted. The flotillas of hunters and their families in canoes arriving in late June continue to use the same sections of beach year after year as landing places. Each band beaching and unloading and later loading for departure customarily appropriates a certain stretch of the short line for its own use. And the family components have theirs. No formality, however, governs the action. Interference does not occur. It is possible to determine from a distance the identity of a family by the station it makes upon its arrival and beaching. The members of the Michikamau band for instance beach and camp at the north end of the sweep of sandy shore beyond the Hudson's Bay post lot. The Ste. Marguerite hunters make their stations nearer the company's grounds.

In the periods of the winter devoted to the business of trapping when the family units of immediate relatives—the small families specifically—break up to resort to the trapping grounds for limited seasons of isolated residence, they distribute themselves habitually in districts preëmpted by long-maintained use. Sylvestre Mackenzie, chief, indicated the principal hunters of his "tribe" and the whereabouts of their customary fur harvesting during the seasons of band disintegration just noted. Corroboration of the locations recorded were given by the men of the band who witnessed the task. The plotting was, however, a somewhat confusing procedure in view of the serious obstacles to be surmounted in identifying and in tracing grounds by well-known names of lakes and rivers which were not shown upon any of the maps obtained for the purpose from the Dominion Geological Survey. The results accordingly are offered with these imperfections well in mind. Mackenzie also stated that locations were made by the hunters subject to his chiefly approval and with general assent by the others having in mind the welfare of the whole horde during the hardest part of the winter. Several of the hunters voluntarily drew sketch maps in pencil of their trapping grounds with the situation of their temporary seasonal camps marked out and the nature of the fur indicated. These are reproduced in figures 1 and 2.

Recorded through the channels of information just mentioned, the family heads and the data pertaining to them appear as follows:

Nabes Gregweneesh, *Wa'tcəkutcec*, "Little woodchuck," a young man married to a daughter of Sylvestre Mackenzie resides with Sylvestre and follows him in his hunting and trapping movements. He marked off his area of operation as lying between Menihek and Dyke lakes when the season of separation for trapping comes. How to assign these hunters to bands is a question. The merging of the socially dissolved Petisikapau band with the families of the Michikamau area under Sylvestre Mackenzie is instanced in the case above where matrilocal residence has taken one of the Gregoire men directly into the Mackenzie family group.

Pien Andre, (26 years old) who bears the sobriquet *Mict Ben*, "Big Ben," traps over an area south of Michikamau Lake toward Attikonak Lake as well as to the southeast of Michikamau. This man prepared a sketch map of the district and movements within it which he and his companions worked the winter of 1924–5. It is reproduced in Fig. 1. One of the observations recorded of him is that he sets 25 marten traps a day on his route. This he regarded as his major harvest in fur.

Openauk, "Black man," traps, whose name is derived from the extreme darkness of skin characteristic of the family.

Bernard Gregoire, son of old Bernard Gregoire who died in 1924, now traps in company with his mother.

Bastien Dominique and one son trap.

David Dominique also traps.

Mathieu *Kabec* and Gabriel *Nisipi·'c* trap as partners northeast of Dyke lake.

Domenique Doctor and adult son constitute a two family partnership.

William Atela'o, also Milwa'tem, "Likes it."

Joseph Germain.

Pierre Germain, *Menoka'bo*, "Stands firmly," and son who is married, make a two family group.

Gregoire *Pətciga't*, "crooked leg," brother of the Gregoire family men who move with the Ste. Marguérite hunters.

Peta'banu, "Brings the dawn."

Joseph Mackenzie, *Wabiya'n to'gi*, "Rabbit ears" so nicknamed from the peculiarity of his ears. Brother to Alexandre and Sylvestre Mackenzie.

Alexandre Mackenzie and son (For illustration of his hunting districts see Fig. 2).

Sylvestre Mackenzie (chief since 1922). Brother to Joseph and Alexandre Mackenzie.

Mathieu *Djokabesh* (*djo'kabec*, the proper name of the Montagnais-Naskapi hero-trickster of mythology, but a name not satisfactorily translated) who is married to the sister of Sylvestre Mackenzie, together with Gabriel Nisipish of a similar relationship, form a trapping partnership, and operate in the spacious area of barrens north of Michikamau Lake and toward Dyke Lake. This group of families usually moves together in ascending and descending from the interior to the coast. It was stated that they hold feasts and

Chart Showing Possible Modes of Development of Both Band and Family Types of Ownership of Hunting Territories Among the Algonkian of the Northeast

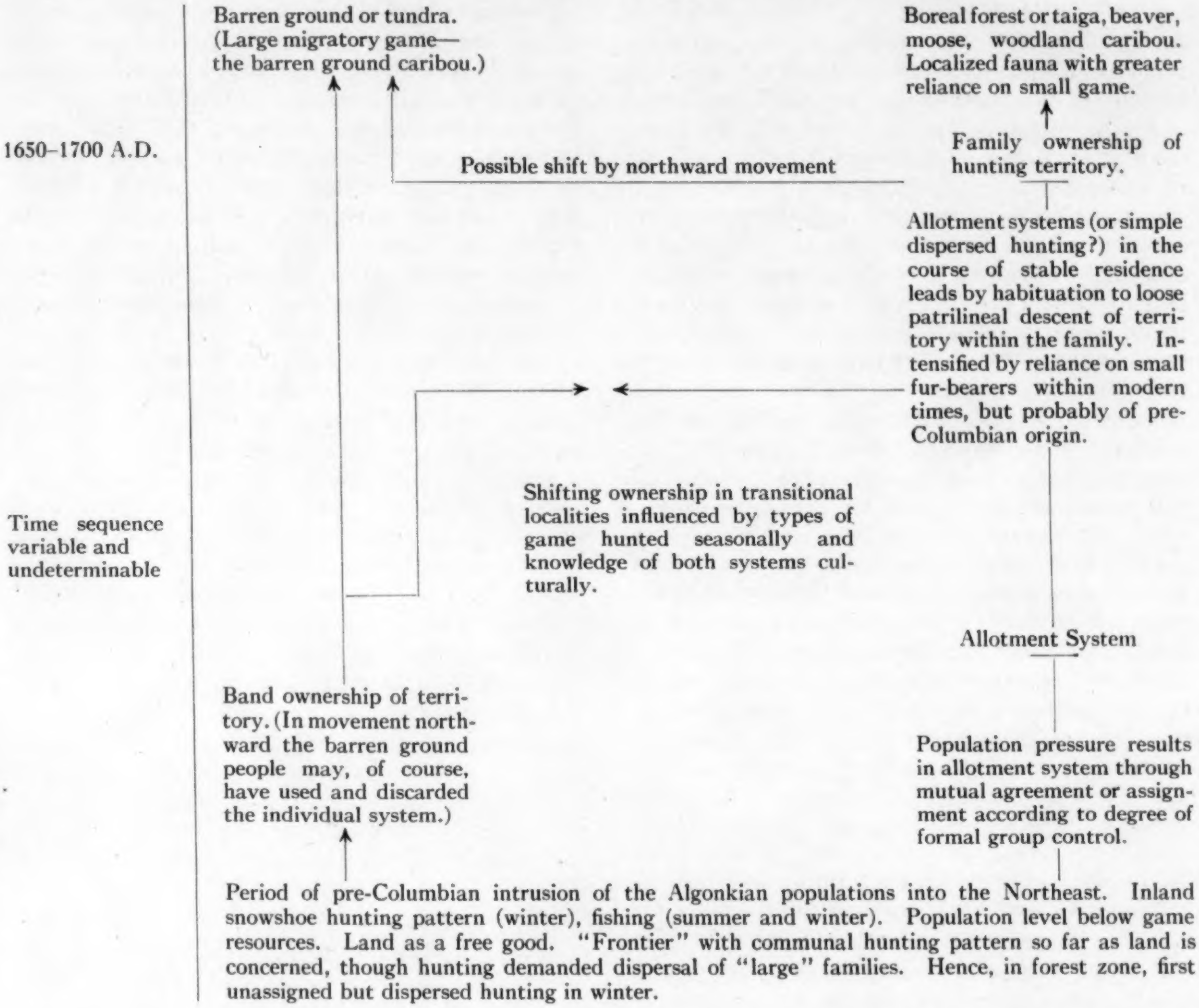

Chart showing distribution of Montagnais-Naskapi Bands of the Lower St. Lawrence and Labrador peninsula, with approximate location of family hunting and trapping districts (1922–25). (Drawn by F. Staniford Speck.)

dances at the times when they depart and arrive at their destinations en route.

John Pierre, or *Wa'pəctan Piel* (*wa'pəctan*, "marten") avowed himself to have been born in the Ungava district, hence a member of the Ungava Band. He still hunts a territory far northward of the grounds frequented by those men previously noted. There were, at the time of contact with him, no feasible means of designating on the map the area he tried to describe. In consideration of the fact that he moves from his grounds down to the coast to trade, joining the migration cycle of the Michikamau hunters, it was thought advisable to list his identity with the latter. This was done partly because of his submission during the treks to the authority of the Michikamau head man Sylvestre Mackenzie and his probable marriage connections there, but chiefly because of his interesting family makeup. *Wa'pəctan Piel*, as he was commonly called, had no son but two daughters nearly of one age. These two women were "wives" at the same time of an active hunter, Ben Kabesh (*Kabe'c*, an alleged shortened form of the name *Djo'kabec* the proper name of the hero-trickster of mythology). It is probable that he is a member of the family of this name which herds with the Michikamau group (see Mathieu Djokabec above). This instance not only illustrates marriage of the sororate pattern but matrilocal residence. By common repute Ben Kabesh married one of the daughters and went to live with his father-in-law in the same tent. It was not long before he had a child by each (of the "wives") in turn. He still dwells with Wápəctan as a partner in the chase. Marten trapping is a major pursuit with these men and is the source of origin for the sobriquet borne by Piel. This incidentally affords a view of the habit of acquiring personal name identity from the principal animal taken and killed by a hunter—personal "game-totemism" *ipse licet.*

It is evident from the information furnished by these men, fragmentary as it is, that the Michikamau band is a vital illustration of the basically communal hunting horde which under force of circumstances modifies its social procedure to the family type of residence during part of the winter. That the annual economic cycle is split into the several types of organization is the feature of importance here in our survey of hunting systems. It next remains to seek out the factors and influences which explain the variations observed and to piece out their historical sequence if possible by logical interpretation.

Conclusion

The conclusions which are derivable from the material we have just surveyed cannot, as yet, be grasped in their entirety. Too much needs still to be done in the field of circumboreal research before it will be possible to weigh to the full the influences, ecological in terms of game hunted, and cultural in terms of established tradition, which form the basis of property ownership among the lower hunters. Approached from the historical standpoint many questions arise. Does band ownership, for example, precede the family system? Does the assignment of land to individual families by the head man, as has been recorded in many instances, precede the direct handing down of territories within the family and is this latter method a purely historical development? Can a widespread succession be observed, or is local adjustment to local exigencies the only observable factor? These and many other questions present themselves for answer. Their shadow must inevitably be troubling to those who, like Morgan, and many present-day Russians, would see the culture of the lower hunters as representing a stage prior to the development of the institution of individualized property. The solution is not easily given because, though ecological patterns seem to have been paramount in the production of the system we have just surveyed, anything which becomes traditional within a human group may be perpetuated, furthered, or modified beyond what might be immediately expected in the case of a new culture intruding into the same environmental background. It may be that this has played its part among the Athapascans who seem to lack the concept save where there exists a reasonable suspicion of Algonkian contact. Elsewhere, the writers have hinted at the functional reasons for the development of the family hunting territory system. Let us attempt a more detailed descent into this pre-Columbian world and see if out of environmental and cultural interplay unmodified by white contact, any evidence exists for sequential stages in the development of an institution which strikes the social theorist as such a curious cultural excrescence to be found among primitive nomadic hunters.

In the first place, it is reasonable to assume that in any new, unpopulated territory being penetrated by wandering hunters small in numbers and not, as yet, pressing heavily upon the game supply, land will tend to represent an economically free good. This will tend to be the case whether or not the requirements of hunting demand united or dispersed effort. It is what we might term the "pioneer" period before the pressure of population and long-term residence create greater territorial consciousness on the part of the group. Such conditions must undoubtedly have fore-run the more intensive ownership patterns now present among the Algonkian hunters, but at what point in their range the change was initiated, how many times duplicated independently or spread by contact, we cannot answer. We can, however, definitely perceive two separate ownership patterns which, as previously indicated, are adjusted to the type of fauna exploited: the band ownership of hunting territory which obtains among those who pursue the migratory caribou herds of the tundra, and the system of family hunting territories, either by mutually agreed seasonal allotment or loose patrilineal inheritance which exists among the hunters of the forest zone who must exploit, in family isolation, the more scattered woodland caribou, the beaver, and like fauna.

Returning, however, to our postulated stage of pioneer penetration and "free" land, it may be seen that as population grows, and, in addition, remains in the new area, increased band concern with the territory and its wild denizens will take place. The band will grow ever more conscious of its dependence on a particular area and food supply.[40] (What indeed were the hunting policies of the plains area but the exhibit of a similar concern under the pressure of a larger, more politically conscious population?) Intrusion of new peoples will be resented. This will be the obvious limit of land consciousness so long as the group is pursuing more or less migratory game, such as the barren ground caribou, in a manner which demands not individual, but group effort. All that has really developed is some added consciousness, perhaps, of group need to protect its area of group exploitation.[41] This, of course, is the sort of situation which Morgan visualized as being omnipresent in the stage of savagery,[42] and implying an entire lack of individual property concepts in land. Land ceases to become a free good as population reaches the survival limit upon it under a given form of economy. The whole history of our pioneer west, from the free range to the coming of the small farmer illustrates this same basic struggle in another guise. Free land is frontier land and, indeed, Speck has observed a tendency for the hunting territories to be more restricted in size where settlement has been longest maintained.[43] Along with their undoubted distinct ecological adjustment the hunters of the subarctic are, in a sense, still pioneers where land is wide and population small. Thus may be postulated Stage I as a period of variable length and circumstance where land is practically valueless because the existing population is not capable of its full exploitation and there is plenty of choice allowable to both the single hunter and the group. This condition, in the case of the localized fauna, results at first in dispersed, but unassigned hunting activities.

Out of a certain degree of permanence of residence will then develop a sense of band territorial possession which, under ecological conditions leading to dispersion of effort in the hunt, may also trend in the direction of individual family exploitation of a given territory. This, it has been noted, may take the form of the allotment system either by the head man arbitrarily assigning territories for a season, or by mutual agreement among the hunters.[44] As we have noted previously this system may exist in conjunction with communal hunting and alternate with it among the same people in some instances.

It may be suspected that the allotment system by choice or assignment preceded the permanent family ownership system since at some point selection must have preceded continual occupation for a long enough period to set up traditional family occupation of one territory. The one, however, could easily pass into the other as

[40] Steward, Julian H., *Basin-Plateau Aboriginal Socio-Politico Groups*, Bulletin 120, Bureau of American Ethnology, Smithsonian Institution, 1938, p. 254. "It may be postulated that habitual use of the resource in question by the family, village, band or other group was a necessary condition for the development of claims to it.' This comment by Steward, for another area, clearly indicates the ubiquity of this working principle.

[41] Herskovits, M. J., *The Economic Life of Primitive Peoples*, Knopf, 1940, p. 292. "Full-fledged communism in land thus means that land has no economic value at all except in so far as the holdings of a given tribe are contrasted with the lands of another entire tribal group whose encroachment on the territory of the first tribe is to be resisted by force."

[42] Morgan, Lewis H., *Ancient Society*, Charles Kerr & Co., Chicago, 1907 edition, p. 537. "Lands as yet hardly a subject of property, were owned by the tribes in common."

[43] Speck, F. G., "Basis of American Indian Ownership of Land," *Old Penn Weekly Review* of the University of Pennsylvania, Vol. 13 No. 16, 1915, p. 495. "Culture Problems in Northeastern North America," *Proceedings of the American Philosophical Society*, Vol. LXV, No. 4, 1926, p. 303.

[44] The allotment system through arbitrary assignment of territories by the headman is somewhat hazily presented in the literature. Dr. Cooper, for example, points to the weak and shifting character of the band and indicates that the so-called "chief" of the early writings may have been no more than the head of a large family splitting up the activities of his dependents upon his own territory by allotment, seasonal or otherwise. Unfortunately, particularly in the early writings, the band, in many cases, is not clearly distinguished from what may have been large land-owning families. In fact, as Steward has been led to suggest, in some cases large families may have eventually become patrilineal bands. The writers have elsewhere pointed out that allotment may also have been of more significance where the office of chief was invested with greater authority. We are inclined to concur with the opinion of Dr. Cooper that the allotment system is strongly in need of clarification and that a good deal of the early literature in particular is somewhat suspect on this point, though not as to the existence of the individual territories. See J. M. Cooper, "Is the Algonkian Family Hunting Ground System Pre-Columbian?" *American Anthropologist*, Vol. 41, 1939, pp. 71–72. Also Julian Steward's "The Economic and Social Basis of Primitive Bands" in *Essays in Anthropology Presented to A. L. Kroeber*, University of California Press, 1936, p. 339; and Speck and Eiseley, *op. cit.*, p. 277.

hunters raised on a particular territory could act more efficiently upon it. Families occupying a particular spot for any length of time would be bound by habit to utilize the territories each knew best and hence patrilineal descent of the loose flexible type which has been noted could be introduced almost imperceptibly. That in modern times true family ownership has been stimulated by the intensive exploitation of the fur-bearing animals may be admitted. Nevertheless, the weighty evidence for pre-Columbian game husbanding of such animals as the beaver is a potent argument for the existence of family territories of something more than a seasonal variety.[45] Why else would such care be taken of this non-migratory beast? Certainly the allotment hunter, unless his allotment were of a pretty permanent nature, would be less interested in restraining his cupidity. In fact Schmidt has argued that one incentive for the establishment of the family territory system lay in the fact that it made for better regulation and husbanding of the game resources and was more easily handled by the head of a family in relation to his children.[46] Indeed he goes so far as to suggest that perhaps the so-called assigning of land by the chief may, in some instances at least, have been no more than the adjustment of inheritance claims.[47]

Where, as in the higher arctic, human population is reduced to such a degree that the individual is forced to move over very wide areas or rely heavily upon the sea, property concepts in land are dimmed even though the life struggle is intense. But below, in the forest zone, where the brooks of a particular watershed may support a localized fauna which with husbanding may support a family in some faint degree of security, the aboriginal will grasp the desirability of outright possession more quickly because human competition in the life struggle is more readily apparent. And with every generation that a particular family holds such a tract where the supply is limited the more firm is the ownership pattern likely to become.[48] It must inevitably confront the careful student of the problems which we have been considering that in the search for the origin of the Algonkian family hunting territory system four approaches are possible. First, the already much discussed historical explanation, linking it with the fur trade—an explanation criticized elsewhere.[49] Second, an explanation entirely in terms of the ecological background. Third, as a survival, culturally, of an archaic Algonkian trait of which the origins are thus merely extended into a more nebulous past. Fourth, an explanation which would emphasize the ecological approach but leave room for the acceptance of possible cultural factors which may have extended or retarded the diffusion of the trait.

Dr. Cooper in his recent excellent survey of the hunting territory system [50] takes some note of ecological factors at work in producing the institution, but, without entering fully into this phase of the discussion, he points out the presence of somewhat similar developments in South America in a few instances, and seems to hint, at least tentatively, at the possibility of the pattern being an archaic survival in the New World. Also he brings forward a genuinely puzzling point—the apparent lack of a similar system among the northern Athapascans even though the beaver range is circumboreal.[51] This is admittedly a difficult problem, in part, we would emphasize, because so little is known in detail of the eastern Athapascan territory. Are we justified, for example, in assuming that conditions *are* entirely the same?

Dr. Steward after an intensive survey of band conditions in all parts of the world has expressed himself as being of the opinion that only rarely would individual land holdings on the hunting level of society be sufficient to sustain life, after the exceptional Algonkian pattern. In this connection, though recognizing our dearth of source

[45] See Speck and Eiseley, *op. cit.*, f. n. 11, p. 273.

[46] Schmidt, W., *Das Eigentum auf den altesten Stufen der Menschheit*, Münster, 1937, Band I, p. 152.

[47] Ibid, p. 154.

[48] Herskovits, *op. cit.*, p. 293. "The emotional attachment of men to the districts where they were born and to the particular localities over which they have exercised proprietary rights, as well as magical and religious considerations, are powerful non-economic forces which must be taken into account."

[49] Probably the most extended defense for the historical origin of the hunting territory system among the Algonkians is to be found in a work by Alfred G. Bailey, entitled *The Conflict of European and Eastern Algonkian Cultures*, New Brunswick Museum, monographic series No. 2, St. John, New Brunswick, 1937. It is interesting in connection with our previous emphasis upon the significance of beaver hunting that Bailey himself (p. 9) admits that the Indians "prize beaver above other animals" not only as food but for clothing, and this before the fur trade had been intensively developed.

[50] Cooper, J. M., "Is the Algonkian Family Hunting Ground System Pre-Columbian?" *American Anthropologist*, Vol. 41, 1939, pp. 66–90.

[51] Ibid, p. 81.

material, the writers would call particular attention to the following facts derived from Dr. Steward's previously mentioned article.[52] He points out in a cursory survey of the Athapaskan area that, in contrast to a population among the Algonkians ranging from one person per 5.3 square miles north of the Great Lakes to one person per 34.6 square miles in the eastern subarctic, the Athapascans average one person per 50 to 80 square miles with "some regions being virtually uninhabited."

We quote further: "The bands of the eastern or mainly Mackenzie Basin Athapascans are extraordinarily large in view of the sparse population, numbering several hundred persons each. This surprising size must be explained by the local economy. There are large herds of migratory musk ox and often caribou in much of the area. These are hunted more or less seasonally and collectively by large groups of people."

The facts just noted suggest a severity of life among the Athapascans not quite comparable to that region in which the hunting territory system achieves its clearest development. Instead we encounter greater reliance upon migratory game and the presence of that constant "frontier" of which we have spoken, where the coöperation of groups moving over wide areas in the struggle for life dims out familial localization and competitiveness. The trap-line ownership coming in in this area is a late development on the part of a people inclined more heavily toward the pursuit of migratory game and only taking up with individualized hunting in a serious manner as the beaver and other small fur-bearers assume more importance economically.[53]

We do not feel that sporadic cultural developments of a similar nature in other portions of the world need necessarily be linked with the Algonkian system as survivals of ancient waves of diffusion. It is not likely, in any case, that so fluid a concept would long survive unless based on group necessity. Certainly its loss among the arctic Algonkian hunters or their casual swing from one practice to another does not encourage its treatment as a static element of culture. Instead we view it as the response to conditions in a forest region not too productive in terms of large game, but having a small fauna (primarily beaver) which could be husbanded and manipulated rather successfully by individual families, whereas a large group might starve on the same territory.[54] Somewhere in the forests south of the barrens or tundra area the pattern began. It is known historically both north and south of the St. Lawrence. Whether apparently similar though less clearly elucidated practices in aboriginal Siberia represent similar adjustment or instead a cultural survival related to Algonkian practice is a difficult problem.

The ecological background conducive to the family exploitation of game resources grows, as we have indicated, out of conditions of family isolation which in turn are caused by the necessity of deriving sustenance from a not too rich, not too easily securable but definitely localized fauna which cannot be hunted communally. Against this background, of course, time will lend the authority of custom and the tradition once established may be intensified and carried far. The Algonkians are old in the forest region. Groups through movement and change of scene may have swung from the communal to the individual method and back again through the vagaries of historic chance. It must be recognized that while we feel the sequence we have indicated must have taken place in the evolution of the family hunting territory system at some point within the forest regions inhabited by the Algonkians; this is not tantamount to the acceptance of the tundra hunters of northern Labrador today as representative of an earlier undeveloped stratum. Indeed it is quite possible that pushing northward into this area of large caribou herds and dearth of localized game, these bands abandoned property concepts acquired in the lower forest reaches where such adjustments

[52] Steward, J. H., "The Economic and Social Basis of Primitive Bands," *Essays In Anthropology Presented to A. L. Kroeber*, University of California Press, 1936, pp. 339–340.

[53] The actual numbers of beaver in various parts of its range are not well known. Its vision is by some writers reputed poor and it needs an abundance of water to best protect itself from wild carnivores such as the lynx and wolverine. Hence to say that it is circumboreal in distribution is not to indicate its exact numerical or ecological importance to man in all parts of its range. Where bigger game was more significant the beaver even when present may not have been, culturally, of so much importance. A systematic, localized and detailed study of faunal-human relationships in the north has still to be made.

[54] H. T. Martin (op. cit. p. 136) emphasizes the winter reliance upon beaver as follows: "When . . . the autumn came, and passed rapidly into the severe winter experienced in nearly the whole of the 'Indian-Beaver' Territory, when the little vegetation that remained was shrouded under a deep covering of snow, when migratory birds, beasts and fishes had abandoned their former haunts, *then the Indian looked on the beaver colony as a providential arrangement to supply his wants.*"

had survival value. Doubtless such reversals of sequence have taken place more than once. Our only contention is that basically the concept of land as a free good must have underlain at some point the rise of the family held tract. Once the latter development takes place, of course, it may, as in the case of any other cultural element, be spread by diffusion among like peoples facing similar environmental necessities. It will not survive or be accepted where communal hunting of migratory game is the chief mode of subsistence. But the very fluidity of the adjustment itself suggests its intimate and sensitive reaction to factors far more heavily natural and environmental than traditional. Such is the nature of the schematized outline, which, for convenient visual purposes we have appended to this paper as an interpretation of the possible general trend of development of this institution throughout the northern woodland. And just as sensitively ecological, it is our firm belief, will prove to be the effect of environment upon land ownership concepts among the other lower hunters who have been less fully investigated at the present time.

With this interpretation in terms of natural background we can more readily cast aside that dubious schematism which persists in viewing the lower hunters as the representatives of an early and primitive collectivism. Instead, we are coming to view these hunters and seed-gatherers as we actually find them—men meeting a variety of environments in variable ways, and diverging accordingly in cultural response.

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